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Land Use and Terrestrial Ecology

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This report was prepared as part of the Ohio River Basin Energy Study (ORBES), a multidisciplinary policy research program supported by the Environmental Protection Agency. It represents the final technical report summarizing land use and terrestrial ecology data and analyses conducted for the study.

The ORBES region consists of all of Kentucky, most of West Virginia, and substantial portions of Illinois, Indiana, Ohio, and Pennsylvania. This 122 million acre region has a variety of land uses, which are summarized here. Also discussed is the terrestrial ecology of the region (climate, physiography, soils, flora, fauna, and ecosystem dynamics). For the various ORBES energy development scenarios, land use conversion due to energy-related use was calculated, and impacts on terrestrial ecology were determined by application of the terrestrial ecosystem assessment methodology developed for ORBES.

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LAND USE AND TERRESTRIAL ECOLOGY

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FOREWORD

The Ohio River Basin Energy Study (ORBES) is an interdisciplinary, multi-university inquiry into the environmental, economic, and social impacts of energy facility development in a major portion of the Ohio River Basin. The study was initiated by the U.S. Environmental Protection Agency in 1976 in response to a directive from the U.S. Senate Appropriations Committee.

Most of the ORBES research was conducted by a group of faculty members at the University of Illinois, Indiana University, the University of Kentucky, the University of Louisville, The Ohio State University, the University of Pittsburgh, Purdue University, and West Virginia University. In a few instances, the necessary expertise was found at other universities or independent research organizations.

This report is one of a series produced in support of the overall ORBES assessment. For a summary of the entire study, see Ohio River Basin Energy Study (ORBES): Main Report, by the ORBES Core Team, also being published by the U.S. Environmental Protection Agency.

ACKNOWLEDGEMENT

A great number of individuals worked together during the four year course of the Ohio River Basin Energy Study. Most have received acknowledgement in other volumes. Those who directly contributed to this volume deserve special mention here: Keith Bobay, Michael Ewert, Olicea Franklin, Jim Kariya, Anne Mackenzie, Cathy Partenheimer, David Skole, Joel Wagner, and Larry Wong.

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SECTION 1

INTRODUCTION

The Ohio River Basin Energy Study (ORBES) began in the fall of 1976 when the U. S. Environmental Protection Agency (EPA) awarded grants to faculty members at a group of universities to carry out initial steps in the assessment of potential environmental, social, and economic impacts of the "proposed concentration" of electrical generating facilities in the lower Ohio River Basin. With the assistance of many additional researchers from other universities and organizations, the ORBES assessment has continued over more than three years through two phases.

1.1 BACKGROUND

In the wake of the 1973-74 Arab oil embargo, many electric utility companies began announcing plans to construct generating facilities in certain portions of the Ohio River Basin. Following these announcements, a variety of social and technological forces became focused on the basin. Concerns over air and water quality were mirrored by concerns for national energy needs. In an effort to identify the implications of locating future energy conversion facilities in the Ohio River Valley, in 1975 the U. S. Senate Appropriations Committee directed EPA to perform a specific study:

> "The committee is aware of plans in various stages of development which could lead to a concentration of power plants along the Ohio River in Ohio, Kentucky, Indiana and Illinois. Although the environmental impacts of such a concentration could be critical, the decision-making authority regarding construction of these facilities is dispersed throughout the federal government and several state governments."
>
> "The committee directs the Environmental Protection Agency to conduct...an assessment of the potential environmental, social, and economic impacts of the proposed concentration of power plants in the Lower Ohio River Basin. This study should be comprehensive in scope, investigating the impacts from air, water, and solid residues on the natural environmental and residents of the region. The study should also take into account the availability of coal and other energy sources in this region" (U. S. Congress, 1975).

Phase I

To carry out the congressional mandate, EPA awarded grants in 1976 to six universities in the lower Ohio River Basin states of Illinois, Indiana, Kentucky and Ohio to produce Phase I of the study. In cooperation with EPA officials, Phase I researchers interpreted the mandate as requesting an assessment tied to the Eastern Interior Coal Province, approximately located in western and southern Illinois, southern Indiana, and western Kentucky. The relationship of this region to the concentrated pattern of proposed power plant construction along some stretches of the lower Ohio River was viewed by Phase I researchers and EPA as the principal focus of the initial year of ORBES. Thus, the boundaries of the region for Phase I included all but the northern tier of counties in Illinois, Indiana and Ohio, and all of Kentucky.

During Phase I, comprehensive scenarios for energy development in the four states were analyzed by three preliminary assessment teams composed of researchers from: (1) Indiana University, Purdue University and The Ohio State University, (2) University of Kentucky and University of Louisville, and (3) Chicago Circle and Urbana-Champaign campuses of the University of Illinois. Phase I findings were integrated and summarized in a publication entitled ORBES PHASE I: Interim Findings (Stukel and Keenan, 1977).

Phase II

Due to concerns that the ORBES Phase I region representated an artificial boundary in the determination of impacts on a total basin system, EPA, university researchers, and congressional leaders involved in initiating ORBES all agreed that the Phase II study region should be expanded to accomodate representative portions of West Virginia and Pennsylvania. Thus, the ORBES Phase II study region (Figure 1-1) includes virtually all of West Virginia and the southwestern portion of Pennsylvania in addition to the original Phase I region.

When Phase II was commenced in the fall of 1977, 13 university faculty members at eight universities served as an interdisciplinary core team of researchers. Core team members included representatives of the six universities involved in Phase I plus researchers from West Virginia University and the University of Pittsburgh. Other research specialists were called upon as needed to fill in critical research gaps as identified by the core team.

The emphasis during Phase II was on performing more detailed analyses of issues raised during Phase I and others as they arose during the assessment. The Phase II work plan elements included the following: (1) completion of the data base, (2) identification of policy issues affecting energy development in the region, (3) construction of plausible future energy scenarios, (4) siting energy facilities for each of the scenarios, and (5) assessing the impacts of each of the scenarios.

This volume represents the final technical report summarizing land use and terrestrial ecology data and analyses conducted during Phase I and II of ORBES. Where necessary, the report draws heavily upon information within: Indiana University et al. 1977; Fowler et al. 1980; Loucks et al. 1980; Willard et al. 1980.

OHIO RIVER BASIN ENERGY STUDY REGION

PHASE II

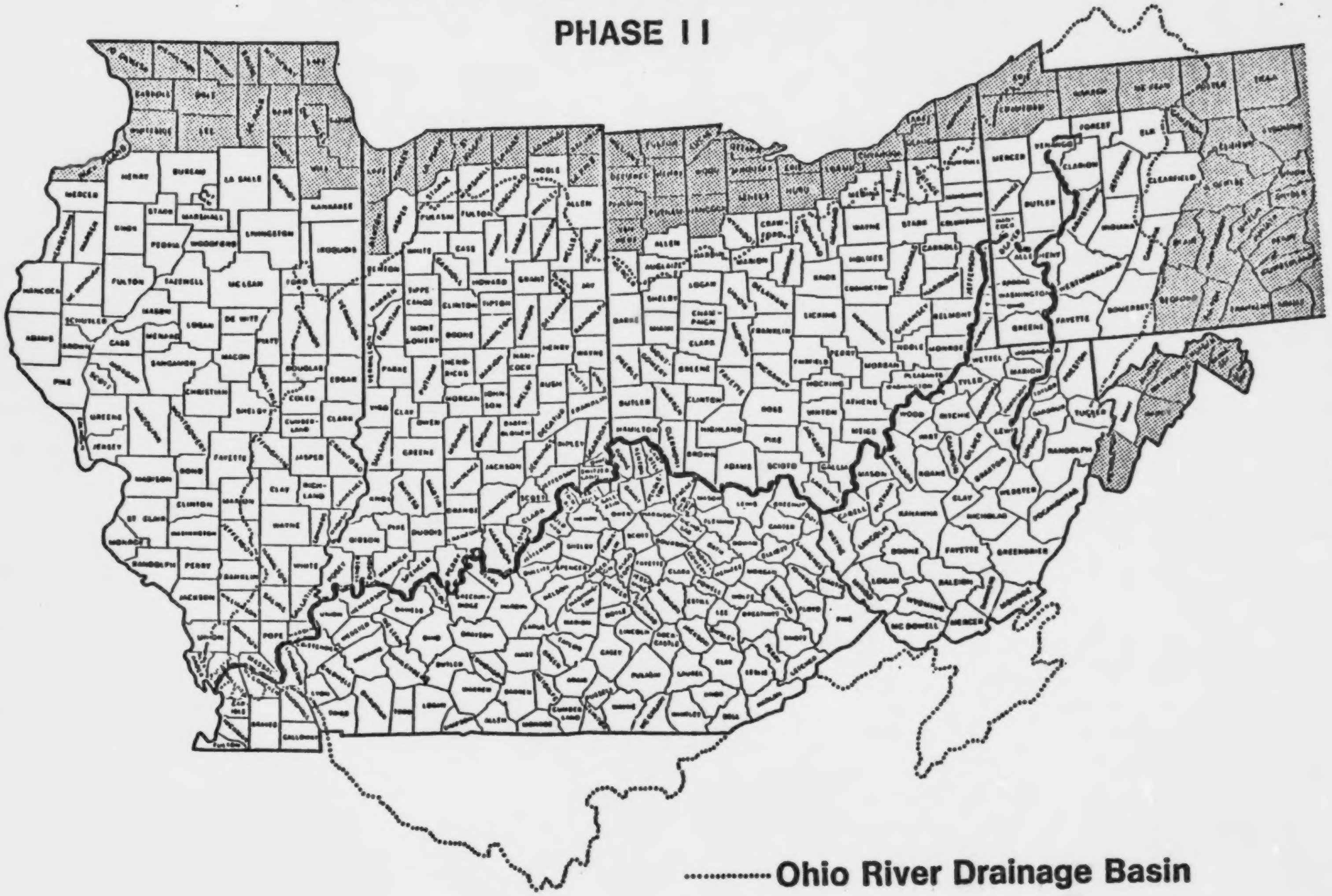

Ohio River Drainage Basin

FIGURE 1-1

SECTION 2

BASELINE ENVIRONMENT

2.1 LAND USE

An understanding of the general patterns of land use within the ORBES region is critical for the analysis of potential land use conversion from present uses to energy-related uses. A regional analysis of major land use types indicates the interrelationships of climate, physiography, soils, vegetation, and the history of human development and the possible constraints on future land uses.

Land Area

The ORBES region covers a total of 121,841,104 acres of land. The greatest amount of ORBES-region land within a single state occurs in Illinois--32.8 million acres (29 percent of total regional land area). The smallest amount is in Pennsylvania, where the ORBES portion constitutes 8.8 million acres (7 percent of total regional land area). Within the ORBES borders of Indiana, Ohio, Kentucky, and West Virginia are 17 percent, 17 percent, 21 percent, and 11 percent of the total regional land area.

Major Land Uses

A generalized land use map of the ORBES region is presented in Figure 2-1. As seen from this map, the region can be roughly divided into two primary land uses: (1) agricultural lands of Illinois, northern Indiana, and northwestern Ohio, and (2) forest lands of southern Indiana, Kentucky, southeastern Ohio, West Virginia, and western Pennsylvania.

Specific land use data at the county level are presented in Tables 2-1 through 2-6 for four major land use categories: agriculture, forest, public, and urban and built-up lands. These land uses were selected for analysis because of their regional importance and because a uniform data base exists for them for all six ORBES states. In some cases county percentages may exceed 100% due to overlap between the public lands category and others. For example, since public lands can include both forest and agricultural lands within their boundaries, these lands could be counted twice. A summary of the land use data for the ORBES region is given in Table 2-7. Distribution maps for each of the four land use categories are presented in Figures 2-2 through 2-5.

The primary land use in the ORBES region is agriculture; these lands constitute about 54 percent of the regional total. Of the ORBES state portions, Illinois has the highest total agricultural land use (23.2 million acres; 71 percent). Indiana has the next greatest amount of agricultural lands (14.4 million acres; 70 percent of the ORBES state portion). Pennsylvania has the lowest amount of agricultural land use (2.2 million acres; 24 percent) and West Virginia the lowest percent (2.4 million acres; 18 percent). Agriculture is the most common land use in the Eastern Interior Coal Province but it is relatively unimportant in the Appalachian Coal Province.

TABLE 2-1. ILLINOIS LAND USE BASELINE DATA

County	Area (Acres)	Agricultural Lands		Forest Lands		Public Lands		Urban and Built-Up Lands	
		Acres	%	Acres	%	Acres	%	Acres	%
Adams	554,240	433,149	78	61,700	11	9,151	2	22,221	4
Alexander	143,400	64,782	45	43,100	30	39,793	24	8,458	6
Bond	245,120	183,779	75	35,700	15	0	0	9,794	4
Brown	196,480	146,626	75	38,200	19	1,500	1	4,525	2
Bureau	555,520	470,010	85	25,600	5	7,415	1	22,954	10
Calhoun	165,650	87,545	53	57,700	35	18,315	11	2,476	1
Cass	236,800	192,885	81	32,000	14	9,872	4	6,369	3
Champaign	640,000	572,900	90	7,100	1	0	0	35,441	6
Christian	453,568	393,792	87	16,466	4	0	0	35,152	8
Clark	323,200	251,414	78	48,000	15	974	1	12,232	4
Clay	296,960	225,865	76	47,100	16	0	0	13,971	5
Clinton	298,694	224,163	75	30,990	10	19,530	7	13,806	5
Coles	324,480	257,924	79	24,084	7	2,019	1	26,161	8
Crawford	282,880	211,980	75	47,400	17	672	1	16,015	6
Cumberland	221,440	175,150	79	24,483	11	0	0	11,671	5
DeWitt	255,360	224,350	88	9,200	4	370	1	15,888	6
Douglas	268,740	247,021	92	4,700	2	0	0	9,488	4
Edgar	401,920	349,481	87	20,312	5	0	0	22,040	5
Edwards	144,000	115,291	80	21,465	15	0	0	4,265	3
Effingham	309,480	213,076	69	54,000	18	320	1	30,195	10
Fayette	458,730	309,289	67	91,500	20	1,882	1	31,905	7
Ford	312,320	283,511	91	1,254	1	0	0	11,028	4
Franklin	277,760	207,882	75	40,119	14	7,702	3	17,043	6
Fulton	559,360	419,754	75	96,338	17	4,751	1	14,613	3
Gallatin	209,900	145,658	69	45,700	22	10,666	5	4,234	2
Greene	347,520	262,711	76	55,962	16	0	0	13,169	4
Grundy	275,980	238,754	87	11,050	4	279	1	9,683	4
Hamilton	278,400	204,586	73	48,713	17	1,683	1	14,577	5
Hancock	510,140	406,840	80	73,900	14	152	1	17,712	3
Hardin	117,120	47,759	41	44,117	38	23,882	20	5,862	5
Henderson	243,840	187,012	77	41,256	17	4,480	2	6,402	3
Henry	528,640	467,511	88	11,500	2	1,090	1	27,063	5
Iroquois	718,080	652,315	91	13,600	2	1,920	1	21,080	3
Jackson	385,800	206,579	54	113,218	29	46,486	12	12,458	3
Jasper	316,800	253,795	80	44,287	14	1,103	1	7,800	2
Jefferson	367,360	279,921	76	44,528	12	2,200	1	20,510	6
Jersey	239,362	162,507	68	52,615	22	10,858	5	6,758	3

Table 2-1 Continued

County	Area (Acres)	Agricultural Lands		Forest Lands		Public Lands		Urban and Built-Up Lands	
		Acres	%	Acres	%	Acres	%	Acres	%
Johnson	219,500	121,671	55	75,600	34	21,502	10	4,765	2
Kankakee	434,700	357,185	82	21,625	5	2,968	1	31,175	7
Knox	465,920	383,896	82	46,500	10	0	0	11,070	2
LaSalle	737,920	647,499	88	31,521	4	4,663	1	29,937	4
Lawrence	239,360	184,525	77	34,000	14	590	1	9,950	4
Livingston	667,520	613,191	92	11,000	2	0	0	22,896	3
Logan	398,080	367,104	92	9,400	2	750	1	15,217	4
McDonough	372,480	307,773	83	26,200	7	1,252	1	25,367	7
McLean	750,720	398,133	93	6,467	1	1,687	1	35,302	5
Macon	368,640	304,558	83	7,490	2	364	1	36,627	10
Macoupin	558,080	444,711	80	75,400	14	737	1	15,100	3
Madison	467,840	300,181	64	54,200	12	465	1	77,296	17
Marion	370,615	255,528	69	72,969	20	3,019	1	23,646	6
Marshall	252,800	206,703	82	23,400	9	4,918	2	5,806	2
Mason	346,240	271,483	78	40,000	12	13,519	4	18,481	5
Massac	157,440	105,087	67	32,622	21	7,552	5	8,406	5
Menard	199,680	174,321	87	14,400	7	520	1	6,224	3
Mercer	355,840	300,900	85	24,300	7	1,400	1	10,581	3
Monroe	243,200	158,481	65	60,000	25	0	0	4,966	2
Montgomery	449,075	367,305	82	48,100	11	0	0	18,151	4
Morgan	301,600	299,203	83	26,100	7	827	1	22,297	6
Moultrie	220,800	194,435	88	4,250	2	9,200	4	7,639	3
Peoria	399,360	288,499	72	39,200	10	2,154	1	43,359	11
Perry	283,500	210,858	74	35,697	13	2,524	1	19,441	7
Piatt	279,680	256,475	92	7,000	3	1	1	10,929	4
Pike	530,560	395,310	75	85,800	16	2,672	1	12,391	2
Pope	243,840	95,295	39	61,072	25	85,706	35	7,312	3
Pulaski	130,600	84,951	65	28,600	22	0	0	9,300	7
Putnam	106,240	75,199	71	13,738	13	0	0	10,889	10
Randolph	380,100	273,854	72	59,808	16	6,612	2	27,094	7
Richland	232,960	189,293	81	26,748	11	3,867	2	12,200	5
St. Clair	428,800	284,816	66	58,300	14	11,278	3	60,224	14
Saline	245,760	164,649	67	34,900	14	14,010	6	17,590	7
Sangamon	563,200	448,446	80	37,195	7	4,067	2	51,912	9
Schuyler	277,760	188,983	68	76,700	28	760	1	5,827	2
Scott	160,640	132,095	82	15,100	9	0	0	5,665	4

Table 2-1 Continued

County	Area (Acres)	Agricultural Lands		Forest Lands		Public Lands		Urban and Built-Up Lands	
		Acres	%	Acres	%	Acres	%	Acres	%
Shelby	494,080	391,977	79	45,177	9	11,214	2	25,884	5
Stark	186,240	171,763	92	5,000	3	0	0	5,722	3
Tazewell	417,920	331,072	79	28,400	7	1,866	1	45,587	11
Union	264,900	146,002	55	76,400	29	43,096	16	7,617	3
Vermilion	574,720	484,817	84	33,543	6	1,760	1	40,753	7
Wabash	141,440	122,982	87	9,215	7	635	1	7,461	5
Warren	346,880	306,562	88	19,600	6	0	0	10,405	3
Washington	361,265	274,687	76	57,218	16	1,417	1	15,226	4
Wayne	457,600	356,076	78	67,858	15	1,301	1	21,330	5
White	320,640	254,336	79	36,700	11	0	0	15,320	5
Williamson	271,900	128,663	47	66,900	25	44,325	16	25,282	9
Woodford	343,680	291,388	85	22,600	7	2,901	1	17,314	5

Sources: (University of Illinois Cooperative Extension Service 1970; Illinois Department of Conservation 1978; Illinois Department of Conservation Undated; U. S. Department of the Interior 1970)

TABLE 2-2. INDIANA LAND USE BASELINE DATA

County	Area (Acres)	Agricultural Lands		Forest Lands		Public Lands		Urban and Built-Up Lands	
		Acres	%	Acres	%	Acres	%	Acres	%
Adams	220,700	190,667	86	15,000	7	0	0	8,978	4
Allen	428,800	317,392	74	35,237	8	0	0	64,000	15
Bartholomew	256,600	161,818	63	34,886	14	20,435	8	16,700	7
Benton	261,700	247,324	95	2,000	1	0	0	6,256	2
Blackford	106,800	87,424	82	10,849	10	0	0	4,400	4
Boone	273,280	230,453	84	11,407	4	6	1	16,398	6
Brown	206,400	29,525	14	135,140	65	58,843	29	2,700	1
Carroll	239,300	205,054	86	16,289	7	0	0	10,050	4
Cass	265,600	213,216	80	18,981	7	0	0	18,800	7
Clark	245,500	104,926	43	90,083	37	16,368	7	29,496	12
Clay	232,960	145,092	62	47,933	21	0	0	11,330	5
Clinton	260,500	231,784	89	9,665	4	0	0	9,870	4
Crawford	199,700	85,219	43	97,454	49	31,276	16	4,730	2
Daviess	275,600	217,004	79	38,643	14	8,200	3	9,547	3
Dearborn	195,800	134,568	69	44,540	23	0	0	8,500	4
Decatur	236,550	196,000	83	23,537	10	24	1	7,000	3
Delaware	253,500	179,781	71	11,534	5	0	0	50,787	20
Dubois	276,800	165,489	60	88,695	32	4,621	2	8,651	3
Fayette	137,600	106,011	77	19,001	14	0	0	3,500	3
Floyd	95,300	40,038	42	37,182	39	0	0	3,500	4
Fountain	254,080	204,011	80	27,440	11	200	1	8,548	3
Franklin	252,100	168,747	67	60,000	24	16,445	7	7,600	3
Fulton	234,900	198,630	85	14,472	6	0	0	7,705	3
Gibson	319,300	252,173	79	45,060	14	7,472	2	12,397	4
Grant	269,500	213,423	79	14,123	5	0	0	23,300	9
Greene	351,300	218,871	62	100,253	29	2,787	1	9,550	3
Hamilton	256,500	195,229	76	13,239	5	0	0	24,826	10
Hancock	195,200	163,872	84	8,469	4	0	0	13,798	7
Harrison	306,500	155,616	51	131,490	43	12,934	4	7,000	2
Hendricks	266,900	194,670	73	17,000	6	0	0	25,610	10
Henry	256,000	199,526	78	17,111	7	800	1	29,800	12
Howard	187,000	157,356	84	7,000	4	0	0	15,477	8
Huntington	249,600	203,019	81	20,430	8	16,747	7	11,200	4
Jackson	332,800	183,762	55	110,323	33	36,028	11	9,400	3
Jasper	359,100	306,924	85	25,613	7	4,500	1	10,108	3
Jay	247,000	211,510	86	19,450	8	0	0	10,400	4
Jefferson	234,300	133,206	57	63,436	27	23,336	10	8,175	3

Table 2-2 Continued

County	Area (Acres)	Agricultural Lands		Forest Lands		Public Lands		Urban and Built-Up Lands	
		Acres	%	Acres	%	Acres	%	Acres	%
Jennings	241,200	138,632	57	69,878	29	4,393	2	7,100	3
Johnson	201,240	154,029	77	8,488	4	5,410	3	21,400	11
Knox	330,900	267,569	79	38,721	12	21	1	15,997	5
Kosciusko	334,300	272,689	82	28,047	8	9	1	23,090	7
Lawrence	293,760	141,091	48	117,416	40	16,162	6	15,767	5
Madison	289,850	226,513	78	15,875	5	254	1	27,200	9
Marion	257,300	86,850	34	12,407	5	0	0	146,887	57
Marshall	284,120	220,875	78	26,678	9	0	0	15,140	5
Martin	220,800	68,075	31	72,996	33	78,306	35	3,100	1
Miami	243,200	201,610	83	18,119	7	2,600	1	9,703	4
Monroe	246,400	85,962	35	110,000	45	56,665	23	24,087	10
Montgomery	324,330	279,584	86	24,000	7	0	0	9,297	3
Morgan	259,700	129,501	50	92,392	36	5,085	2	14,423	6
Noble	262,400	206,730	79	25,524	10	2,678	1	9,603	4
Ohio	55,680	38,137	68	14,567	27	0	0	1,576	3
Orange	259,059	118,254	46	102,770	40	27,906	11	5,650	2
Owen	246,400	116,152	47	115,000	47	11,231	5	4,988	2
Parke	286,570	175,420	61	86,595	30	6,877	7	9,841	3
Perry	245,760	94,987	39	94,300	38	58,656	24	6,495	3
Pike	214,400	117,987	55	77,951	36	10,270	5	5,800	3
Posey	264,900	212,243	80	32,973	12	4,400	2	6,473	2
Pulaski	277,100	220,983	80	32,000	12	5,846	2	7,294	3
Putnam	312,320	202,767	65	72,000	23	937	1	13,000	4
Randolph	292,500	258,551	88	13,226	5	0	0	10,385	4
Ripley	282,600	182,685	65	55,525	20	5,905	2	8,400	3
Rush	261,700	232,713	89	12,851	5	0	0	7,800	3
Scott	123,400	68,268	55	43,592	35	7,189	6	8,000	6
Shelby	261,760	235,179	90	7,607	3	0	0	9,300	4
Spencer	253,400	167,656	66	69,780	28	1,747	1	5,721	2
Starke	199,000	134,657	68	27,000	14	2,324	1	13,038	7
Sullivan	292,500	225,679	77	54,791	19	5,816	2	7,350	3
Switzerland	141,440	100,292	71	36,490	26	0	0	2,500	2
Tippecanoe	320,600	248,695	78	24,571	8	0	0	18,705	5
Tipton	167,000	142,127	85	10,000	6	0	0	7,600	5
Union	107,080	80,580	75	15,000	14	1,515	1	4,604	4

Table 2-2 Continued

County	Area (Acres)	Agricultural Lands		Forest Lands		Public Lands		Urban and Built-Up Lands	
		Acres	%	Acres	%	Acres	%	Acres	%
Vanderburgh	154,200	92,619	60	18,736	12	0	0	29,006	19
Vermillion	168,300	118,888	71	30,346	18	0	0	7,707	5
Vigo	265,600	167,948	63	45,000	17	26	1	32,300	12
Wabash	269,400	219,504	81	20,552	8	15,689	6	13,000	5
Warren	235,500	194,869	83	23,350	10	0	0	5,556	2
Warrick	249,700	114,030	46	72,479	29	87	1	11,300	5
Washington	330,120	176,097	53	130,891	40	10,896	3	5,826	2
Wayne	258,900	181,018	70	23,000	9	9	1	32,000	12
Wells	235,500	203,641	86	17,333	7	1,065	1	8,405	4
White	318,000	287,691	90	12,807	4	0	0	9,598	3
Whitley	215,000	174,348	81	20,102	9	0	0	7,946	4

Sources: (Purdue University Cooperative Extension Service 1968; Indiana Department of Natural Resources 1978; Indiana Department of Natural Resources Undated; Indiana Department of Natural Resources 1975)

TABLE 2-3. KENTUCKY LAND USE BASELINE DATA

County	Area (Acres)	Agricultural Lands		Forest Lands		Public Lands		Urban and Built-Up Lands	
		Acres	%	Acres	%	Acres	%	Acres	%
Adair	251,520	131,191	52	108,880	43	0	0	4,939	2
Allen	232,960	131,696	57	83,800	36	2,600	1	3,819	2
Anderson	131,840	91,278	69	34,100	26	0	0	4,179	3
Ballard	165,760	119,606	72	36,793	22	10,194	6	3,169	2
Barren	311,040	214,558	69	72,131	23	3,399	1	10,016	3
Bath	183,680	123,441	67	42,543	23	19,186	10	540	3
Bell	236,000	6,976	3	202,171	85	14,100	6	9,577	4
Boone	161,280	104,532	65	44,400	27	864	1	6,985	4
Bourbon	192,000	173,801	91	5,100	3	0	0	3,851	2
Boyd	102,400	34,333	34	57,200	56	0	0	7,104	7
Boyle	117,120	87,059	74	20,100	17	565	1	5,651	5
Bracken	130,560	86,119	66	39,600	30	0	0	2,010	2
Breathitt	361,160	22,250	6	279,585	77	10,000	3	4,755	1
Breckinridge	360,960	181,520	50	160,000	44	6,155	2	8,160	2
Bullitt	192,000	69,432	36	74,600	39	42,855	22	4,857	3
Butler	283,520	124,789	44	135,500	48	0	0	4,884	2
Caldwell	228,480	122,411	54	79,200	35	1,929	1	19,109	8
Calloway	245,760	134,357	55	77,100	31	1,000	1	10,431	4
Campbell	95,360	34,663	36	18,800	18	900	1	37,490	39
Carlisle	124,800	75,550	61	42,400	34	237	1	2,606	2
Carroll	83,200	49,240	59	26,600	32	809	1	3,447	4
Carter	257,280	65,652	26	181,900	70	9,100	4	6,638	3
Casey	278,400	115,607	42	153,800	55	0	0	5,989	2
Christian	464,640	293,575	63	131,400	28	29,635	6	13,980	3
Clark	165,760	140,273	85	12,200	7	0	0	5,133	3
Clay	303,360	45,491	15	247,600	82	72,549	24	3,424	1
Clinton	121,600	53,361	44	61,209	50	5,950	5	1,562	1
Crittenden	233,600	130,051	56	87,800	37	0	0	5,149	2
Cumberland	198,400	70,418	35	117,656	59	3,900	2	1,286	1
Daviess	295,680	204,440	69	66,200	22	303	1	14,275	5
Edmonson	194,560	71,847	37	67,796	35	53,600	28	3,776	2
Elliott	153,600	35,892	23	114,100	74	350	1	2,096	1
Estill	166,400	34,562	21	117,982	71	3,955	2	3,826	2
Fayette	179,200	140,387	78	5,500	3	1,042	1	21,742	12
Fleming	224,000	156,146	70	60,300	27	0	0	4,650	2
Floyd	255,360	33,227	13	192,600	75	10,350	4	3,754	1
Franklin	135,040	74,530	55	44,700	33	124	1	10,966	8

Table 2-3 Continued

County	Area (Acres)	Agricultural Lands		Forest Lands		Public Lands		Urban and Built-Up Lands	
		Acres	%	Acres	%	Acres	%	Acres	%
Fulton	129,920	88,594	68	32,300	25	2,040	2	5,480	4
Gallatin	64,000	41,431	65	19,600	30	0	0	1,820	3
Garrard	151,040	119,948	79	23,800	16	0	0	3,880	3
Grant	159,360	118,980	75	38,400	24	1,579	1	1,265	1
Graves	358,400	248,624	69	80,200	22	0	0	12,517	3
Grayson	327,680	195,420	60	115,760	35	4,477	1	5,706	2
Green	180,480	111,848	62	60,200	33	0	0	4,690	3
Greenup	224,640	53,461	24	158,000	70	3,330	1	4,925	2
Hancock	119,680	56,194	47	56,800	47	0	0	2,613	2
Hardin	394,240	201,250	51	100,000	25	48,000	12	14,297	4
Harlan	300,160	7,173	2	260,600	87	6,388	2	10,691	4
Harrison	197,120	153,804	78	33,500	17	0	0	4,475	2
Hart	272,000	139,520	51	107,705	39	1,530	1	5,180	2
Henderson	277,120	190,517	69	61,300	22	5,935	2	9,246	3
Henry	184,960	129,724	70	44,800	24	0	0	4,496	2
Hickman	157,440	113,769	72	37,900	24	456	1	3,613	2
Hopkins	353,920	144,243	41	160,332	45	853	1	12,898	4
Jackson	215,680	47,775	22	109,273	50	56,196	26	4,279	2
Jefferson	240,000	101,325	42	33,500	14	397	1	77,222	32
Jessamine	113,280	91,502	81	12,200	11	0	0	5,202	5
Johnson	168,960	25,410	15	136,900	81	0	0	3,406	2
Kenton	105,600	40,965	39	28,200	27	747	1	32,100	30
Knott	227,840	14,388	6	197,600	87	0	0	5,448	2
Knox	238,720	42,524	18	177,700	74	86	1	5,970	3
Larue	166,400	99,458	60	55,700	33	100	1	3,567	2
Laurel	285,440	80,173	28	140,867	49	57,185	20	9,598	3
Lawrence	272,000	40,906	15	222,800	82	0	0	5,088	2
Lee	134,400	20,792	15	102,312	76	7,012	5	2,544	2
Leslie	263,680	6,583	2	228,500	86	52,083	20	3,967	2
Letcher	216,960	19,077	9	186,939	86	11,435	5	4,312	2
Lewis	311,040	62,384	20	238,578	76	6,600	2	6,101	2
Lincoln	217,600	145,402	67	58,700	27	11	1	2,100	1
Livingston	199,680	109,675	55	73,300	37	400	1	3,808	2
Logan	360,320	229,962	64	109,700	30	0	0	9,338	3
Lyon	161,920	31,241	19	28,222	17	42,200	26	8,000	5
McCracken	160,000	87,078	54	37,600	23	9,028	6	21,462	13
McCreary	267,520	13,057	5	92,838	35	170,114	63	1,704	1

Table 2-3 Continued

County	Area (Acres)	Agricultural Lands		Forest Lands		Public Lands		Urban and Built-Up Lands	
		Acres	%	Acres	%	Acres	%	Acres	%
McLean	164,480	108,703	66	45,500	28	0	0	4,207	3
Madison	285,440	205,895	72	49,200	17	3,321	1	8,134	3
Magoffin	193,920	28,292	15	161,000	83	0	0	3,187	2
Marion	219,520	122,435	56	82,800	37	0	0	4,515	2
Marshall	193,920	104,865	54	66,100	34	5,083	3	12,300	6
Martin	147,840	10,282	7	130,100	88	0	0	1,714	1
Mason	152,320	127,482	84	18,500	12	0	0	3,874	3
Meade	195,200	93,636	48	75,800	39	3,000	2	4,791	2
Menifee	134,401	20,811	15	79,387	59	40,386	30	2,470	2
Mercer	163,840	136,507	83	17,600	10	18	1	5,510	3
Metcalfe	189,440	95,721	51	88,000	46	0	0	3,919	2
Monroe	213,760	105,768	49	99,000	46	30	1	4,089	2
Montgomery	130,560	106,043	81	18,700	14	0	0	3,110	2
Morgan	236,160	53,021	22	165,470	70	9,533	4	3,489	1
Muhlenberg	307,840	137,644	45	140,900	45	338	1	6,284	2
Nelson	279,680	144,992	52	117,200	42	4,235	2	8,627	3
Nicholas	130,560	102,699	79	23,900	18	5,659	4	2,192	2
Ohio	381,440	160,151	42	195,800	51	150	1	12,411	3
Oldham	117,760	82,962	70	22,200	19	209	1	5,640	5
Owen	224,640	138,603	62	81,000	36	1,254	1	2,120	1
Owsley	126,080	23,880	19	92,799	73	15,957	13	2,302	2
Pendleton	178,560	119,975	67	50,500	28	448	1	3,938	2
Perry	219,520	9,826	4	187,200	85	4,989	2	4,569	2
Pike	503,040	29,964	6	425,173	84	10,116	2	7,199	1
Powell	110,720	21,939	20	69,969	63	16,502	15	4,859	4
Pulaski	418,560	185,330	44	178,420	42	27,954	7	6,154	1
Robertson	64,640	45,646	71	16,300	25	100	1	1,674	3
Rockcastle	199,040	50,048	25	129,128	65	12,418	6	6,249	3
Rowan	185,600	39,146	21	92,555	50	61,489	33	3,417	2
Russell	152,320	57,593	38	62,563	41	13,399	9	12,154	8
Scott	181,760	148,637	82	25,600	14	0	0	3,025	2
Shelby	245,120	194,617	79	31,400	13	0	0	6,223	3
Simpson	152,960	116,770	76	23,300	15	0	0	6,750	4
Spencer	123,520	92,530	75	24,600	20	0	0	2,532	2
Taylor	181,760	92,935	51	65,800	36	1,300	1	1,300	1
Todd	240,640	170,166	71	61,700	26	16	1	5,294	2
Trigg	293,760	89,517	30	52,587	18	84,600	29	20,000	7
Trimble	93,440	55,341	59	34,600	37	0	0	1,938	2

Table 2-3 Continued

County	Area (Acres)	Agricultural Lands		Forest Lands		Public Lands		Urban and Built-Up Lands	
		Acres	%	Acres	%	Acres	%	Acres	%
Union	217,600	140,934	65	37,594	17	5,420	2	6,166	3
Warren	349,440	235,064	67	90,600	26	0	0	9,641	3
Washington	196,480	137,886	70	47,100	24	153	1	4,974	3
Wayne	281,600	80,508	29	178,941	64	12,142	4	400	1
Webster	216,960	132,120	61	67,800	31	0	0	5,635	3
Whitley	293,760	50,543	17	196,566	67	44,798	15	9,434	3
Wolfe	145,280	33,023	23	92,622	64	14,887	10	3,645	3
Woodford	123,520	102,893	83	8,700	7	285	1	3,930	3

Sources: (Kentucky Conservation Needs Inventory Committee 1970; D. M. Stine 1977; Kentucky Department of Parks 1978; Kentucky Department of Fish and Wildlife Resources 1977; Kentucky Department of parks 1978)

TABLE 2-4. OHIO LAND USE BASELINE DATA

County	Area (Acres)	Agricultural Lands		Forest Lands		Public Lands		Urban and Built-Up Lands	
		Acres	%	Acres	%	Acres	%	Acres	%
Adams	376,320	163,365	43	187,100	50	18,340	5	11,702	30
Allen	262,400	189,848	72	23,010	9	1,274	1	30,840	12
Ashland	267,520	182,438	68	51,383	19	4,726	2	16,208	6
Athens	322,290	108,844	34	180,043	56	29,557	9	18,949	6
Auglaize	256,000	205,375	80	20,840	8	3,100	1	17,824	7
Belmont	342,273	170,427	50	124,492	36	7,591	2	24,127	7
Brown	314,019	215,984	69	76,800	24	2,014	1	11,239	4
Butler	301,240	173,960	58	31,793	11	3,102	1	68,007	23
Carroll	248,320	115,943	47	113,800	46	8,970	4	11,177	5
Champaign	277,064	219,239	79	32,804	12	1,455	1	17,119	6
Clark	257,177	187,645	73	23,875	9	10,564	4	34,760	14
Clermont	292,920	149,618	51	91,000	31	2,759	1	35,434	12
Clinton	263,040	217,699	83	17,113	7	7,024	3	15,754	6
Columbiana	342,103	195,631	57	88,768	26	6,603	2	43,804	13
Coshocton	348,800	164,857	47	148,400	43	6,224	2	16,838	5
Crawford	258,485	198,791	77	25,080	10	221	1	18,638	7
Darke	387,150	320,836	83	24,515	6	449	1	23,319	6
Delaware	281,600	219,694	78	26,739	9	17,620	6	20,205	7
Fairfield	323,200	236,241	73	52,138	16	1,685	1	19,963	6
Fayette	259,840	228,210	88	11,867	5	2,277	1	12,775	5
Franklin	343,680	172,900	50	19,671	6	1,219	1	129,813	38
Gallia	300,991	120,613	40	154,600	51	11,055	4	11,647	4
Greene	266,060	200,630	75	19,000	7	1,722	1	25,497	10
Guernsey	332,160	153,921	46	155,400	47	20,181	6	18,267	5
Hamilton	264,960	45,163	17	33,409	13	0	0	171,855	65
Hardin	298,880	252,227	84	20,324	7	15	1	15,238	5
Harrison	257,920	103,260	40	138,700	54	13,954	5	10,634	4
Highland	352,640	246,416	70	84,200	24	12,527	4	13,493	4
Hocking	268,650	59,681	22	173,084	64	42,997	16	10,118	4
Holmes	270,520	159,065	59	93,500	35	6,018	2	9,893	4
Jackson	268,256	99,693	37	141,200	53	9,689	4	16,121	6
Jefferson	268,040	70,507	26	148,200	56	6,586	3	31,806	12
Knox	334,720	231,699	69	68,507	20	2,742	1	20,766	6
Lawrence	291,840	63,575	22	169,200	58	56,530	19	15,212	5
Licking	439,040	294,762	67	86,262	20	2,124	1	36,407	8

Table 2-4 Continued

County	Area (Acres)	Agricultural Lands		Forest Lands		Public Lands		Urban and Built-Up Lands	
		Acres	%	Acres	%	Acres	%	Acres	%
Logan	295,040	231,843	79	30,495	10	6,452	2	14,709	5
Madison	296,660	262,266	88	13,275	4	183	1	12,058	4
Mahoning	268,160	95,511	36	31,026	12	5,405	2	77,326	29
Marion	259,200	203,263	78	23,861	9	2,904	1	17,762	7
Medina	271,200	173,297	64	41,814	15	870	1	19,598	7
Meigs	277,610	89,514	32	168,100	61	3,333	1	11,945	4
Mercer	290,560	243,653	84	23,438	8	12,200	4	15,314	5
Miami	260,480	210,091	81	18,901	7	16	1	21,647	8
Monroe	291,200	116,667	40	147,606	51	15,972	5	13,386	5
Montgomery	297,600	156,251	53	18,250	6	268	1	108,707	37
Morgan	266,880	128,544	48	115,000	43	8,923	3	9,482	4
Morrow	258,560	194,224	75	46,235	18	172	1	11,004	4
Muskingum	424,320	210,288	50	175,600	41	19,571	5	24,437	6
Noble	255,140	117,361	46	115,700	45	6,913	3	11,183	4
Perry	261,760	107,464	41	116,500	45	23,899	9	14,340	5
Pickaway	324,375	285,046	88	12,566	4	4,474	1	13,137	4
Pike	283,520	113,222	40	151,698	54	11,142	4	8,172	3
Portage	319,320	147,675	46	89,327	28	10,619	3	36,206	11
Preble	273,280	217,495	80	25,538	9	1,808	1	14,738	5
Richland	318,080	191,903	60	70,759	22	4,379	1	37,086	12
Ross	439,680	237,114	54	170,300	44	31,743	7	16,607	4
Scioto	389,760	89,116	23	254,500	65	65,716	17	25,466	7
Shelby	261,760	211,866	81	23,550	9	1,708	1	14,425	6
Stark	366,720	175,934	48	67,120	18	6,747	2	86,458	24
Summit	264,229	59,449	22	46,411	18	4,760	2	124,042	47
Trumbull	391,145	137,630	35	86,224	22	28,155	7	60,638	16
Tuscarawas	352,640	162,762	46	156,300	44	3,180	1	9,996	3
Union	277,760	229,678	83	18,638	7	30	1	20,620	7
Vinton	263,040	49,459	19	193,900	74	49,665	19	37,537	14
Warren	261,120	178,027	68	33,042	13	5,250	2	7,680	3
Washington	407,680	124,171	30	239,500	59	28,845	7	21,151	5
Wayne	352,640	258,582	73	52,870	15	2,134	1	25,101	7
Wyandot	259,017	213,499	82	24,957	10	8,993	3	10,046	4

Sources: (Ohio Soil and Water Conservation Needs Committee 1971; Melvin 1970; Ohio Department of Natural Resources 1977a; Ohio Department of Natural Resources 1976a; Ohio Department of Natural Resources 1977b; Ohio Department of Natural Resources 1976b; Ohio Department of Natural Resources Undated)

TABLE 2-5. PENNSYLVANIA LAND USE BASELINE DATA

County	Area (Acres)	Agricultural Lands		Forest Lands		Public Lands		Urban and Built-Up Lands	
		Acres	%	Acres	%	Acres	%	Acres	%
Allegheny	467,200	41,013	9	86,278	18	1,423	3	254,968	55
Armstrong	419,840	128,065	31	218,900	52	5,843	1	24,871	6
Beaver	282,240	81,398	29	134,600	48	8,756	3	46,000	16
Butler	508,160	153,572	30	261,600	26	24,557	5	36,500	7
Cambria	444,800	94,332	19	284,600	64	20,401	5	31,900	7
Clarion	383,360	78,900	21	272,600	71	21,284	6	22,700	6
Clearfield	732,160	55,547	8	607,900	83	104,515	14	36,916	5
Elk	516,480	19,662	4	360,364	70	238,328	46	13,754	3
Fayette	508,160	111,360	22	317,300	62	42,732	8	40,302	8
Forest	266,240	6,712	3	138,066	52	118,700	45	4,833	2
Greene	369,280	190,528	52	147,752	40	10,317	3	19,500	5
Indiana	528,000	160,487	30	289,400	55	11,126	2	34,000	6
Jefferson	417,280	74,220	18	292,813	70	47,748	11	26,181	6
Lawrence	234,880	92,761	39	92,700	39	4,968	2	20,000	9
Mercer	435,840	185,518	43	147,625	34	8,103	2	44,631	10
Somerset	693,760	169,864	24	443,400	64	50,363	7	34,404	5
Venango	432,000	47,440	11	352,700	82	32,194	7	18,500	4
Washington	548,480	265,041	48	192,703	35	11,041	2	50,200	9
Westmoreland	654,720	209,998	32	312,100	48	14,043	2	69,448	11

Sources: (Pennsylvania Soil Conservation Service 1970; Key et al. 1979; Pennsylvania Department of Environmental Resources 1975a; Pennsylvania Department of Environmental Resources 1975b; Pennsylvania Department of Environmental Resources 1977)

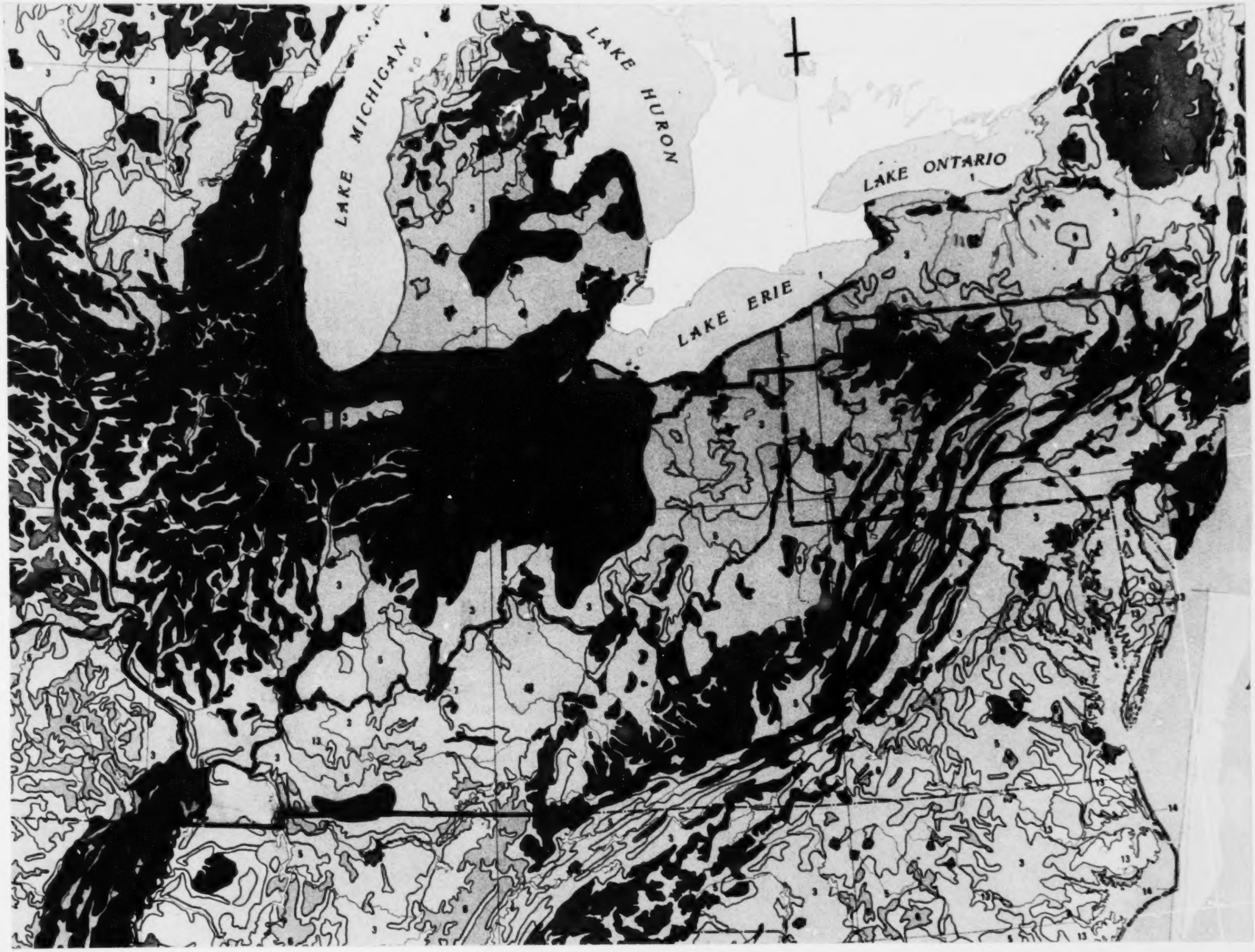
TABLE 2-6. WEST VIRGINIA LAND USE BASELINE DATA

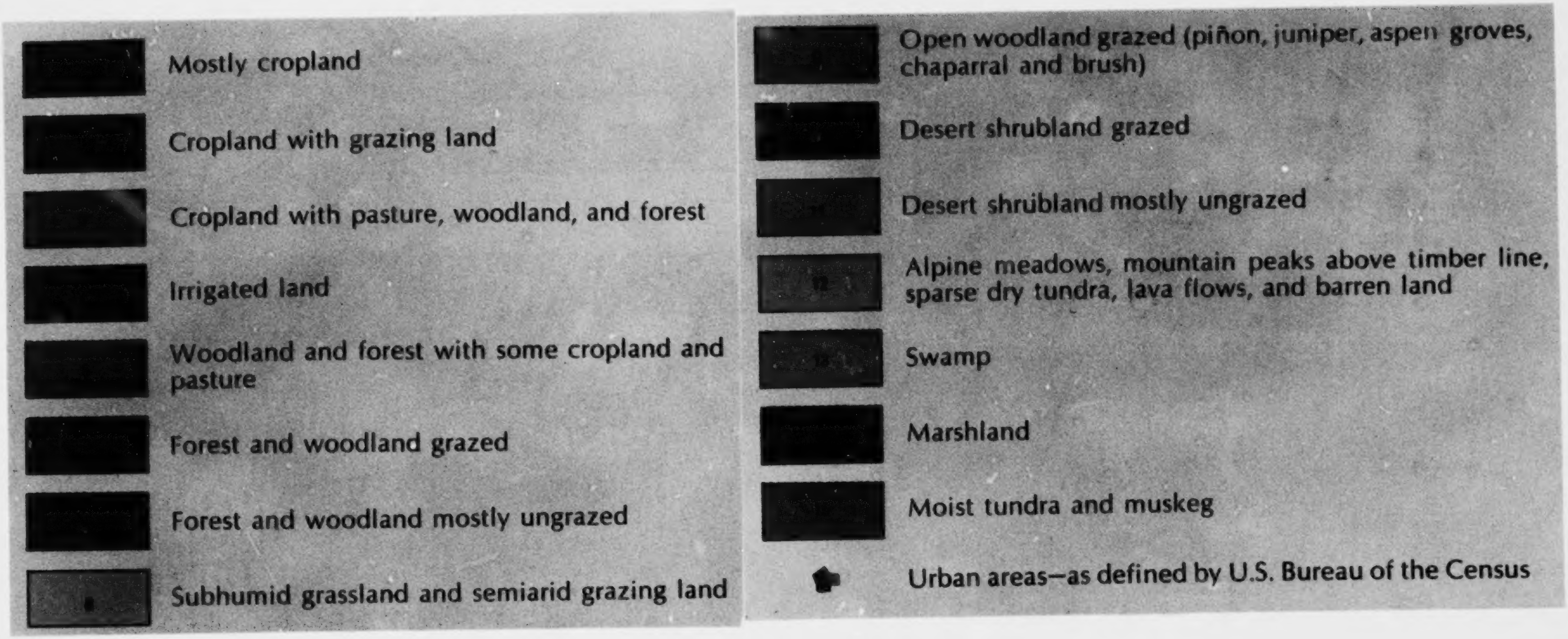
County	Area (Acres)	Agricultural Lands		Forest Lands		Public Lands		Urban and Built-Up Lands	
		Acres	%	Acres	%	Acres	%	Acres	%
Barbour	215,040	64,772	30	130,327	61	2,141	1	5,998	3
Boone	320,600	3,200	1	290,000	90	9,000	3	9,800	3
Braxton	330,900	87,855	27	213,633	65	17,187	5	6,100	2
Brooke	57,000	14,100	25	23,900	42	133	1	7,600	13
Cabell	178,560	30,334	17	118,203	66	0	0	19,403	11
Calhoun	179,800	33,135	18	138,600	77	0	0	2,802	2
Clay	218,900	22,062	10	189,350	87	0	0	3,200	1
Doddridge	204,200	40,587	20	149,625	[illegible]	0	0	3,200	2
Fayette	421,760	35,400	8	352,400	84	6,866	2	22,800	5
Gilmer	217,000	42,370	20	167,468	77	2,167	1	3,999	2
Grant	304,190	56,815	19	219,014	72	17,030	6	3,015	1
Greenbrier	656,480	134,982	21	401,860	61	106,514	16	9,542	1
Hancock	52,500	11,600	22	24,600	47	1,398	3	11,100	21
Harrison	267,520	98,643	37	115,079	43	530	1	13,509	5
Jackson	296,320	72,678	25	206,179	70	64	1	9,000	3
Kanawha	581,100	46,000	8	453,500	78	9,052	2	49,700	9
Lewis	250,900	89,691	36	134,300	54	2,389	1	5,187	2
Lincoln	280,320	25,246	9	245,545	88	7,155	3	3,519	1
Logan	291,800	3,700	1	260,500	89	3,305	1	14,100	5
McDowell	341,120	3,999	1	302,500	89	25,896	8	16,821	5
Marion	197,800	50,000	25	120,000	61	188	1	14,800	7
Marshall	195,800	71,642	37	110,920	57	62	1	7,496	4
Mason	276,400	98,878	36	162,304	59	13,135	5	7,511	3
Mercer	266,900	47,470	18	186,445	70	7,142	3	14,702	6
Mingo	270,720	2,000	1	242,300	90	12,850	5	12,512	5
Monongalia	233,500	42,489	18	144,940	62	6,350	3	12,505	5
Monroe	302,600	108,837	36	185,035	61	100,895	33	4,995	2
Nicholas	412,600	44,995	11	312,923	76	23,696	6	6,826	2
Ohio	68,500	29,156	43	21,407	31	199	1	11,497	17
Pleasants	83,200	9,668	12	68,910	83	0	0	2,009	2
Pocahontas	603,520	93,354	15	209,431	35	317,367	52	5,200	1
Preston	412,800	101,300	25	273,700	66	10,380	3	10,493	3
Putnam	223,400	44,849	20	166,986	75	0	0	6,663	3
Raleigh	386,230	56,346	15	295,115	76	1,691	1	21,230	5
Randolph	663,100	84,489	13	383,218	58	187,029	28	10,393	2
Ritchie	289,280	83,211	29	197,200	30	6,405	2	6,510	2
Roane	311,000	95,200	31	197,800	64	0	0	6,000	2
Summers	228,900	48,856	21	152,321	67	22,777	10	5,007	2
Taylor	108,800	38,359	35	55,900	51	4,109	4	4,000	4

Table 2-6 Continued

County	Area (Acres)	Agricultural Lands		Forest Lands		Public Lands		Urban and Built-Up Lands	
		Acres	%	Acres	%	Acres	%	Acres	%
Tucker	269,400	22,500	8	139,600	52	101,492	38	4,000	1
Tyler	163,800	51,540	31	105,716	65	355	1	3,206	2
Upshur	225,300	76,810	34	131,400	58	2,535	1	5,000	2
Wayne	328,320	41,900	13	270,300	82	8,123	2	7,134	2
Webster	352,600	13,470	4	266,099	75	73,119	20	3,311	1
Wetzel	231,700	23,496	10	196,067	85	9,176	4	5,616	2
Wirt	149,800	33,664	22	109,932	73	5,127	3	2,500	2
Wood	235,500	63,152	27	145,900	62	0	0	15,098	6
Wyoming	322,600	16,000	5	287,637	89	3,823	1	8,563	3

Sources: (West Virginia Soil Conservation Service 1970; West Virginia Department of Natural Resources Undated a; West Virginia Department of Natural Resources Undated b)


LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE



■ Mostly cropland
■ Cropland with grazing land
■ Cropland with pasture, woodland, and forest
■ Irrigated land
■ Woodland and forest with some cropland and pasture
■ Forest and woodland grazed
■ Forest and woodland mostly ungrazed
■ Subhumid grassland and semiarid grazing land
■ Open woodland grazed (piñon, juniper, aspen groves, chaparral and brush)
■ Desert shrubland grazed
■ Desert shrubland mostly ungrazed
■ Alpine meadows, mountain peaks above timber line, sparse dry tundra, lava flows, and barren land
■ Swamp
■ Marshland
■ Moist tundra and muskeg
● Urban areas—as defined by U.S. Bureau of the Census

Figure 2-1. Generalized land use map of the ORBES region.

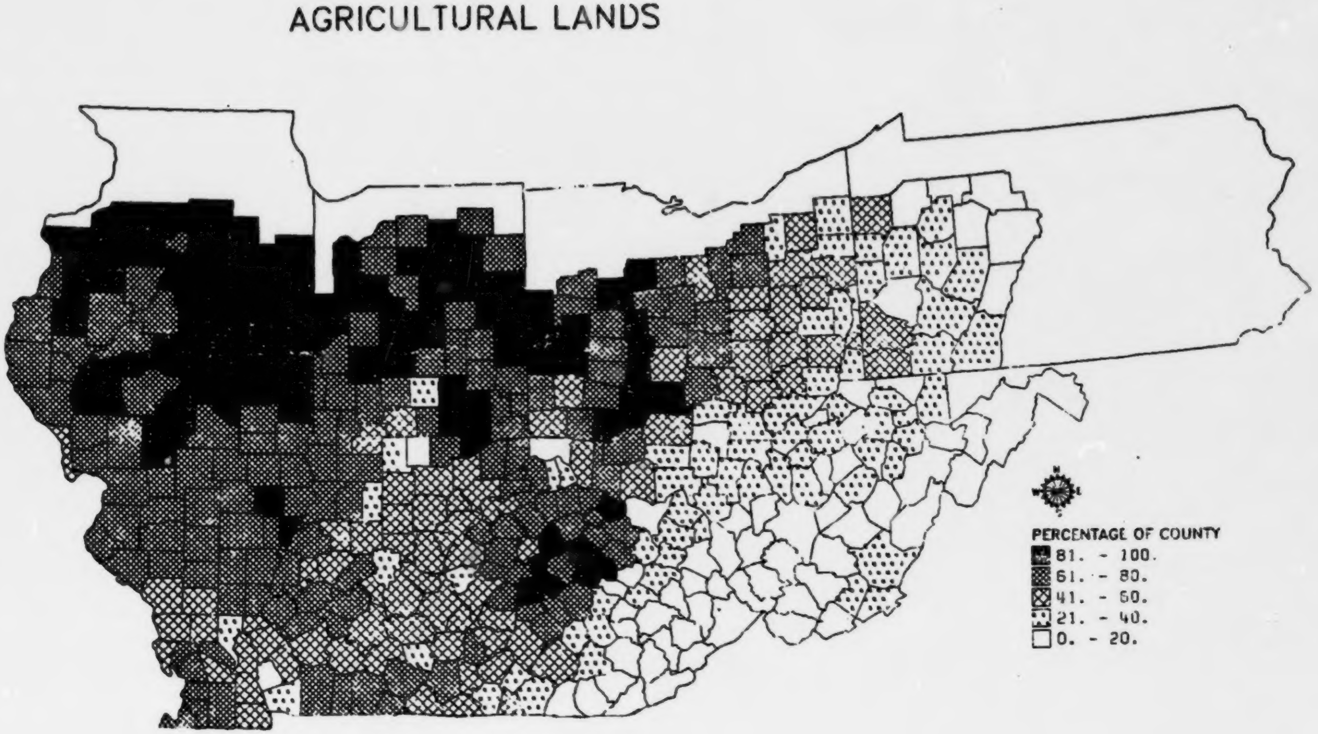
TABLE 2-7. SUMMARY OF LAND USE DATA FOR THE ORBES REGION

State	ORBES Acres	%	Public Lands Acres	%	Urban and Built-Up Lands Acres	%	Agricultural Lands Acres	%	Forest Lands Acres	%
Illinois	32,797,350	27	547,164	2	1,538,052	5	23,170,488	71	3,275,470	10
Indiana	20,595,959	17	429,190	2	1,200,095	6	14,433,705	70	3,556,697	17
Ohio	20,620,254	17	699,439	3	1,957,523	9	11,761,622	57	5,659,823	27
Kentucky	25,555,881	21	1,445,622	6	834,818	3	11,751,700	46	10,988,246	43
Pennsylvania	8,842,880	7	776,442	9	829,608	9	2,156,418	24	4,953,481	56
West Virginia	13,428,780	11	1,128,852	8	445,172	3	2,410,800	18	9,276,089	69
ORBES Region	121,841,104	100	5,026,709	4	6,805,268	6	65,684,733	54	37,709,806	31

The second most common land use in the ORBES region is forest land which constitutes 31 percent of the regional total. The Kentucky ORBES portion has the greatest total forest land use (11.0 million acres; 43 percent). The highest percentage of land in forest use is in West Virginia (9.3 million acres; 69 percent). Of the ORBES state portions, Illinois has the least amount (3.3 million acres) and lowest percentage (10 percent) of forested land, due to both limited natural forests and extensive conversion to agriculture. Forests are the most common land use in the Appalachian Coal Province but are relatively unimportant in the Eastern Interior Coal Province.

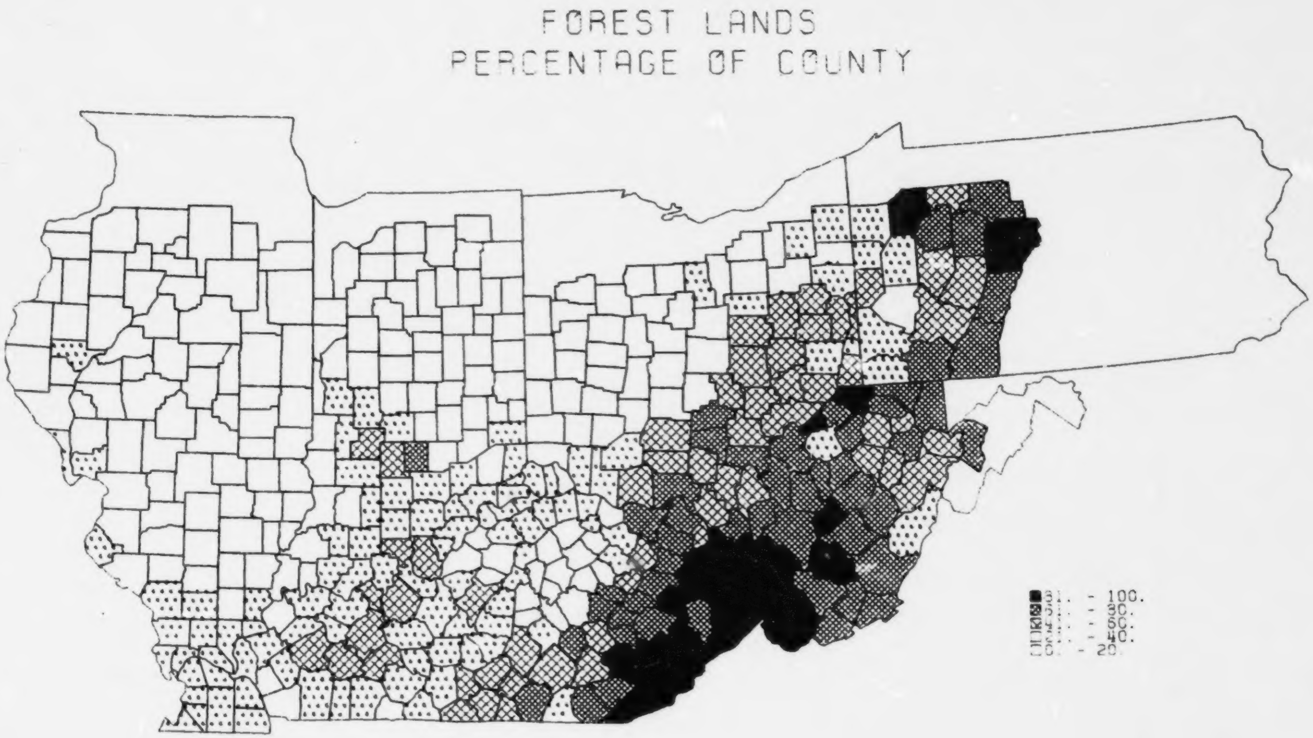
Approximately 6 percent of the ORBES region is in urban and built-up lands. The greatest amount and percentage of this land use occur in the ORBES state portion of Ohio (2.0 million acres; 9 percent) while the lowest state portion occurs in West Virginia (0.4 million acres; 3 percent).

Of the four categories analyzed, public lands constitute the least amount of land use, approximately 4 percent of the regional total. Public lands are defined as those in either state or federal ownership and are generally held aside for recreational uses. The greatest total public lands land use occurs in the Kentucky state portion (1.4 million acres; 6 percent). The highest percentage of public lands occurs in the Pennsylvania state portion (0.8 million acres; 9 percent). The lowest total and percentage of public lands land use occur in the Indiana state portion (0.4 million acres; 2 percent).


AGRICULTURAL LANDS
PERCENTAGE OF COUNTY
81. - 100.
61. - 80.
41. - 60.
21. - 40.
0. - 20.

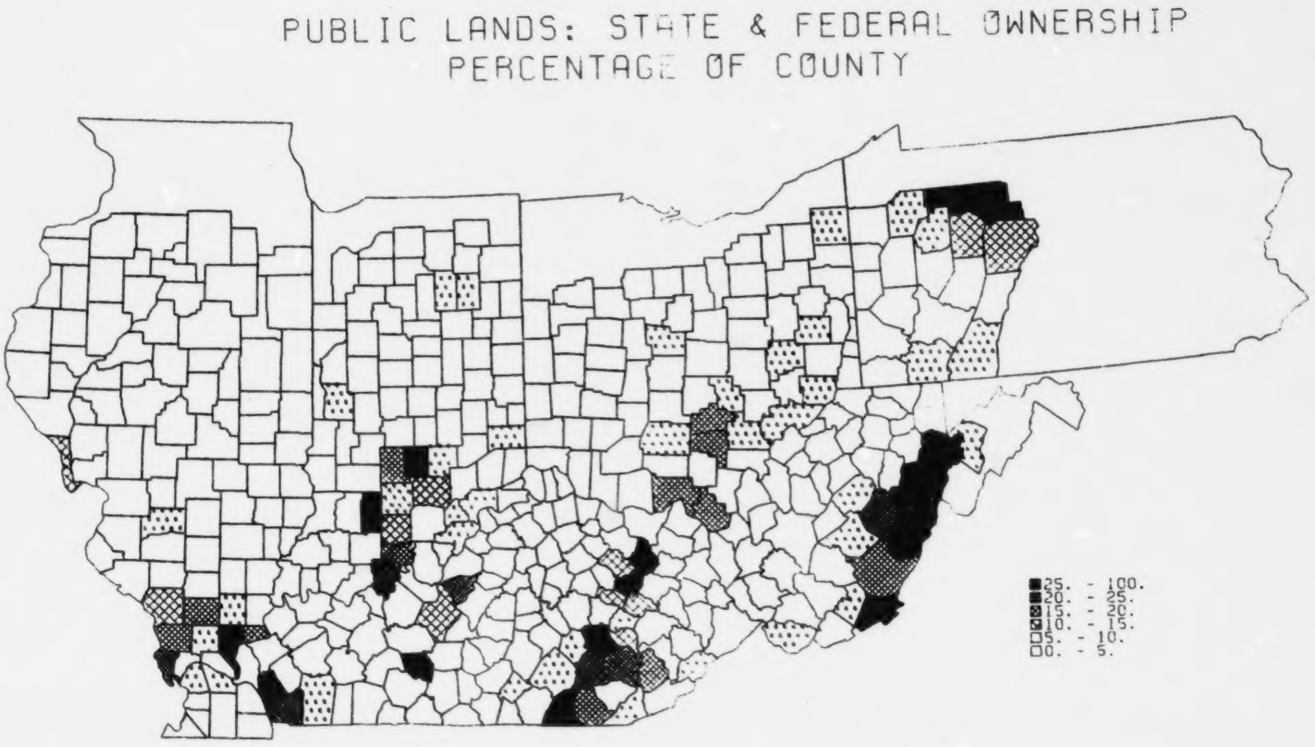
PREPARED FOR OHIO RIVER BASIN ENERGY STUDY
BY CAGIS/UICC, FEBRUARY, 1980

FIGURE 2-2. AGRICULTURAL LANDS DISTRIBUTION


FOREST LANDS
PERCENTAGE OF COUNTY
81. - 100.
61. - 80.
41. - 60.
21. - 40.
0. - 20.

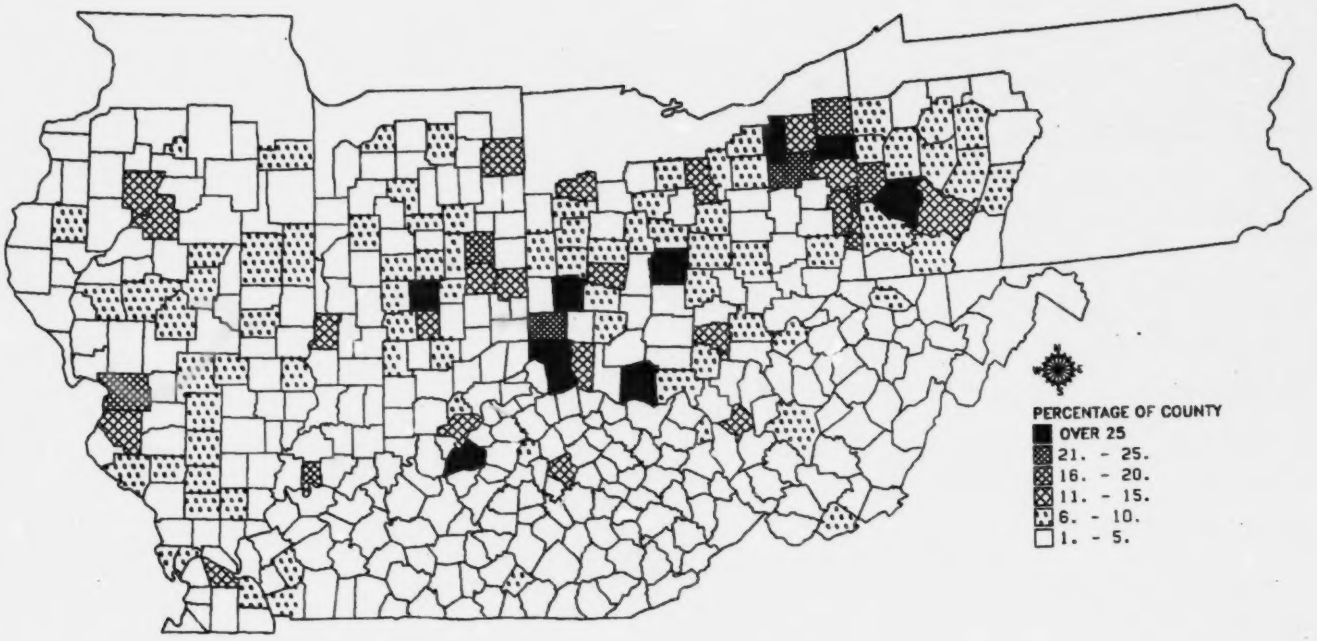
PREPARED FOR INDIANA UNIVERSITY SPEA
BY CAGIS UICC SEPT 1979

FIGURE 2-3. FOREST LANDS DISTRIBUTION


PUBLIC LANDS: STATE & FEDERAL OWNERSHIP
PERCENTAGE OF COUNTY
25. - 100.
20. - 25.
15. - 20.
10. - 15.
5. - 10.
0. - 5.

PREPARED FOR INDIANA UNIVERSITY SPEA
BY CAGIS UICC. SEPT 1979

FIGURE 2-4. PUBLIC LANDS DISTRIBUTION



URBAN AND BUILT-UP LANDS
N
S
E
W
PERCENTAGE OF COUNTY
■ OVER 25
▩ 21. - 25.
▩ 16. - 20.
▩ 11. - 15.
▨ 6. - 10.
☐ 1. - 5.

PREPARED FOR OHIO RIVER BASIN ENERGY STUDY
BY CAGIS/UICC, FEBRUARY, 1980

FIGURE 2.5. URBAN AND BUILT-UP LANDS DISTRIBUTION

2.2 TERRESTRIAL ECOLOGY

This section is an attempt to summarize a very large volume of information describing the terrestrial ecology of the ORBES region.[1] The data describing the terrestrial features of the ORBES region are highly variable in quantity and quality. As there are no standardized sets of variables that are routinely monitored and reported, either on an interstate or intrastate level, the level of resolution of the information varies from extremely detailed, site-specific data to very generalized, nonquantitative overviews.

Because political boundaries rarely follow natural ecological or physiographic patterns, there are always difficulties in describing the natural features of an area when the data are available from several sources in several states. For purposes of this presentation the integrative concept of a biome will be used. A biome is any area where regional climates and substrates interact with regional biota to form large, recognizable, geographically-based units.

Climate

The annual solar radiation and mean annual precipitation patterns are fairly similar throughout the ORBES region. Although there is a pattern of decreasing precipitation from east to west across the region, the regional climate can be considered fairly uniform.

Physiography

While there are certain similarities among the terrestrial ecosystems of the ORBES region, it is obvious that the hilly and mountainous terrain of the upper Ohio River Basin presents a different physiographic setting than that of the largely glaciated lowlands in the lower Ohio River Basin. The primary physiographic subdivisions of the ORBES region are the Appalachian Highlands of West Virginia, Pennsylvania, southeastern Ohio, and eastern Kentucky; the Eastern Interior Uplands of western Kentucky, southern Indiana, and southern Illinois; and the Central Lowlands of western Ohio, northern Indiana, and most of Illinois. A more detailed presentation of the primary land-surface forms is seen in Figure 2-6.

Soils

Three major soil classes follow a similar pattern: inceptisols (weakly developed, usually light, thin soils with low organic matter) in the Appalachian Highlands, mollisols (deep, nearly black, organic rich soils) in the

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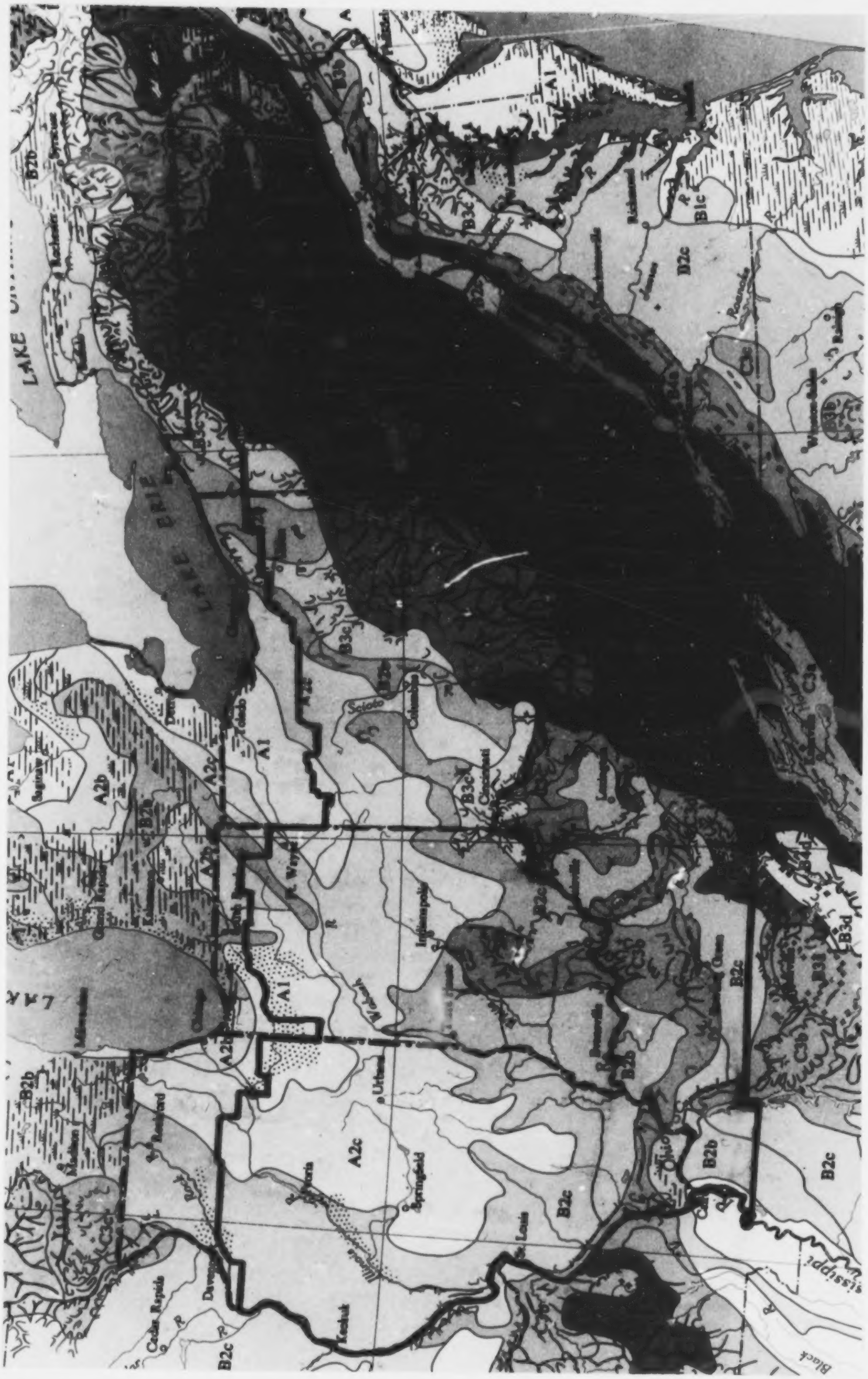
[1] Most of the material presented here is taken from the preliminary technology assessment reports prepared by the Indiana-Ohio, Illinois, and Kentucky assessment teams during Phase I (Indiana University, The Ohio State University, and Purdue University 1977; University of Kentucky and University of Louisville 1977; University of Illinois at Chicago Circle and at Urbana-Champaign 1977) and from the baseline data reports from West Virginia (Cardi 1979) and Pennsylvania (Kay et al. 1979).


LAKE ONTARIO
LAKE ERIE
LAKE
Rochester
Syracuse
Richmond
Roanoke
Winston-Salem
Detroit
Saginaw
Grand Rapids
Toledo
Ft. Wayne
Columbus
Scioto
Cincinnati
Indianapolis
Lexington
Louisville
Milwaukee
Chicago
Madison
Rockford
Urbana
Peoria
Springfield
St. Louis
Davenport
Cedar Rapids
Keokuk
Wabash
Ohio
Mississippi
Black
A1
A2b
A2c
B1c
B2b
B2c
B3b
B3c
B3d
C3a
C3b
C3c

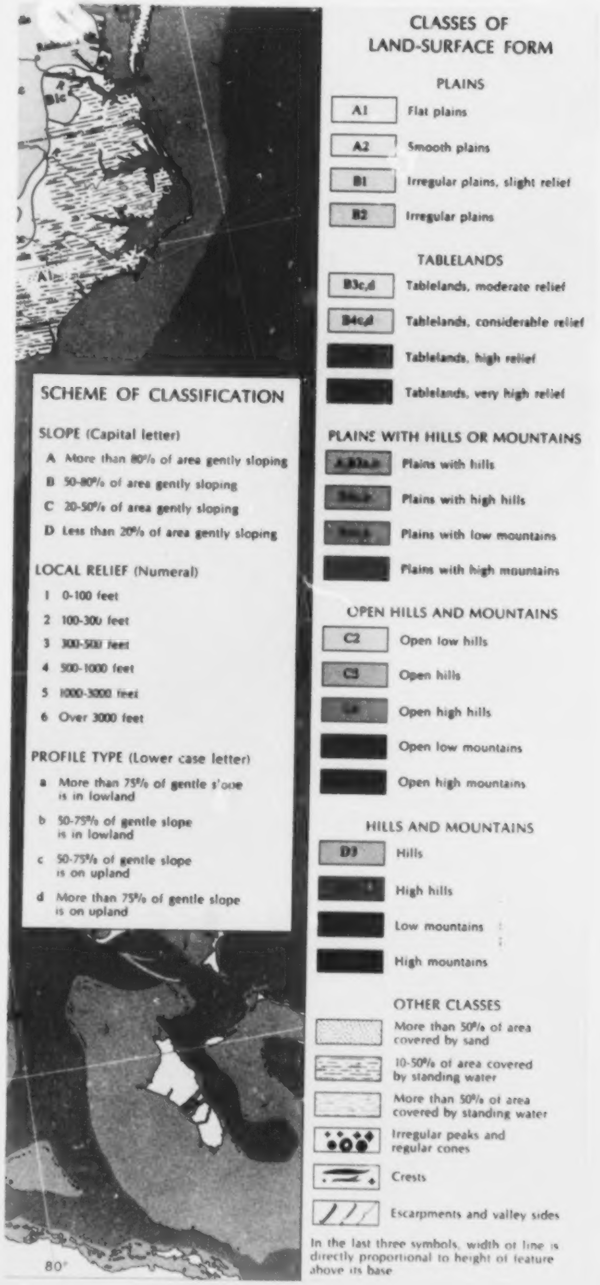

SCHEME OF CLASSIFICATION
SLOPE (Capital letter)
A More than 80% of area gently sloping
B 50-80% of area gently sloping
C 20-50% of area gently sloping
D Less than 20% of area gently sloping
LOCAL RELIEF (Numeral)
1 0-100 feet
2 100-300 feet
3 300-500 feet
4 500-1000 feet
5 1000-3000 feet
6 Over 3000 feet
PROFILE TYPE (Lower case letter)
a More than 75% of gentle slope is in lowland
b 50-75% of gentle slope is in lowland
c 50-75% of gentle slope is on upland
d More than 75% of gentle slope is on upland
CLASSES OF LAND-SURFACE FORM
PLAINS
A1 Flat plains
A2 Smooth plains
B1 Irregular plains, slight relief
B2 Irregular plains
TABLELANDS
B3c,d Tablelands, moderate relief
B4c,d Tablelands, considerable relief
Tablelands, high relief
Tablelands, very high relief
PLAINS WITH HILLS OR MOUNTAINS
Plains with hills
Plains with high hills
Plains with low mountains
Plains with high mountains
OPEN HILLS AND MOUNTAINS
C2 Open low hills
C3 Open hills
Open high hills
Open low mountains
Open high mountains
HILLS AND MOUNTAINS
D3 Hills
High hills
Low mountains
High mountains
OTHER CLASSES
More than 50% of area covered by sand
10-50% of area covered by standing water
More than 50% of area covered by standing water
Irregular peaks and regular cones
Crests
Escarpments and valley sides
In the last three symbols, width of line is directly proportional to height of feature above its base
80°

Figure 2-6. Primary land surface forms in the ORBES region.

Eastern Interior Uplands, and alfisols (well-developed, gray to brown, podzolic, moist mineral soils) in the Central Lowlands. This pattern is seen in Figure 2-7.

Flora

Potential Vegetation--

From these patterns of regional climates and substrates it is possible to develop patterns of potential natural vegetation. Potential natural vegetation is defined as the vegetation that would exist if human beings were not affecting the natural ecosystems and only natural ecosystem development (succession) were occurring. This potential natural vegetation indicates the biotic potential of all locations and is indicative of patterns of presettlement vegetation.

The patterns of potential natural vegetation of the ORBES region are seen in Figure 2-8. These patterns reflect both physiographic and climatological influences. The primary patterns are northern hardwoods of eastern West Virginia; mixed mesophytic forests of western West Virginia, southeastern Ohio, and eastern Kentucky; Appalachian oak forest of western Pennsylvania, northern West Virginia, and eastern Ohio; beech-maple forest of northern and western Ohio, and northern and central Indiana; oak-hickory forest of central and western Kentucky, southern Indiana, and southern Illinois; and bluestem prairie of central and northern Illinois (all according to terminology of Kuchler, 1966). The first five of these are a part of a larger, recognizable unit often referred to as the Eastern Deciduous Forest Biome.

Prior to settlement by European immigrants, broadleaf deciduous forests occupied about 90 percent of the ORBES region lying within Illinois, Indiana, Ohio, and Kentucky and all of the ORBES region in West Virginia and Pennsylvania. The distributions and compositions of these presettlement communities are believed to follow the patterns of potential natural vegetation shown in Figure 2-8.

Post-settlement Changes--

The major changes in the original vegetation brought about by settlement have been the conversion of forest and prairie into agricultural land. On many of the glaciated soils in the northern part of the ORBES region, trees have been eradicated, except along fencelines and waterways and in ravines. Large portions of northwestern Ohio and northern Indiana have undergone major land use conversion from beech-maple forests to agriculture. Virtually all of the Illinois prairie has been converted to agricultural land use. The portions of the region along the Ohio River in the lower basin and in the Appalachian Highlands have been subjected to much less deforestation, primarily because of physiographic constraints. The more rugged and unglaciated terrain is not suited for intensive agriculture and is not widely used for grazing. Unforested lands predominate on ridge tops and valley bottoms; forests cover slopes, bluffs, and banks of large rivers.

Present Vegetation--

The present patterns of vegetation in the ORBES region are shown in Figure 2-9. Table 2-8 gives brief descriptions of the major forest types appearing in Figure 2-9. The acreages and percentages of forest resources by county and by state are given in Tables 2-1 through 2-6. The term "forest resource" as used here refers to much more than the commercial aspects of timber production. Forests provide habitats for many wildlife species, offer numerous and varied recreational opportunities for humans, are important in watershed soil and hydrological dynamics, and serve as regulators in nutrient uptake and release in biogeochemical cycles. Kentucky has the highest total acreage of forests in the ORBES region, and West Virginia has the highest percentage of land in forest land use. Because of both the relatively limited extent of naturally occurring forests and the great extent of conversion to tillage, Illinois has the least amount of forest resources.

Fauna

Original Fauna--

The original fauna of the ORBES region was predominantly a deciduous woodland fauna. ("Fauna" as used here describes terrestrial and amphibious vertebrates.) Wetland faunas were well represented, although somewhat localized inasmuch as wetlands were extensive only along the northern border of the ORBES region. Other localized faunas included those of prairies, caves, and rock outcroppings and other forms of steep relief. The only fauna that was, and is, largely endemic to the ORBES region, and thus unique, is the karst (cave) fauna, which is especially well represented in southern Indiana, Kentucky, and southeastern West Virginia.

Post-settlement Changes--

Following human settlement there was selective elimination of the larger animals, followed by the assisted return of deer, beavers, and wild turkeys. Patchwork clearing of forests permitted certain prairie and forest edge species to increase in numbers at the expense of species of the forest proper; for example, fox squirrels replaced gray squirrels, opossums and raccoons became more numerous, and bobcats became rarer. Many amphibian, reptile, and bird species characteristic of rivers in the ORBES region appear to be declining in population, though the causes of this have not been adequately studied. On the other hand, several large impoundments in the Ohio coal counties, especially in the southeastern Muskingum River watershed, serve as new stopping points for large numbers of ducks and geese.

Game Animals and Furbearers--

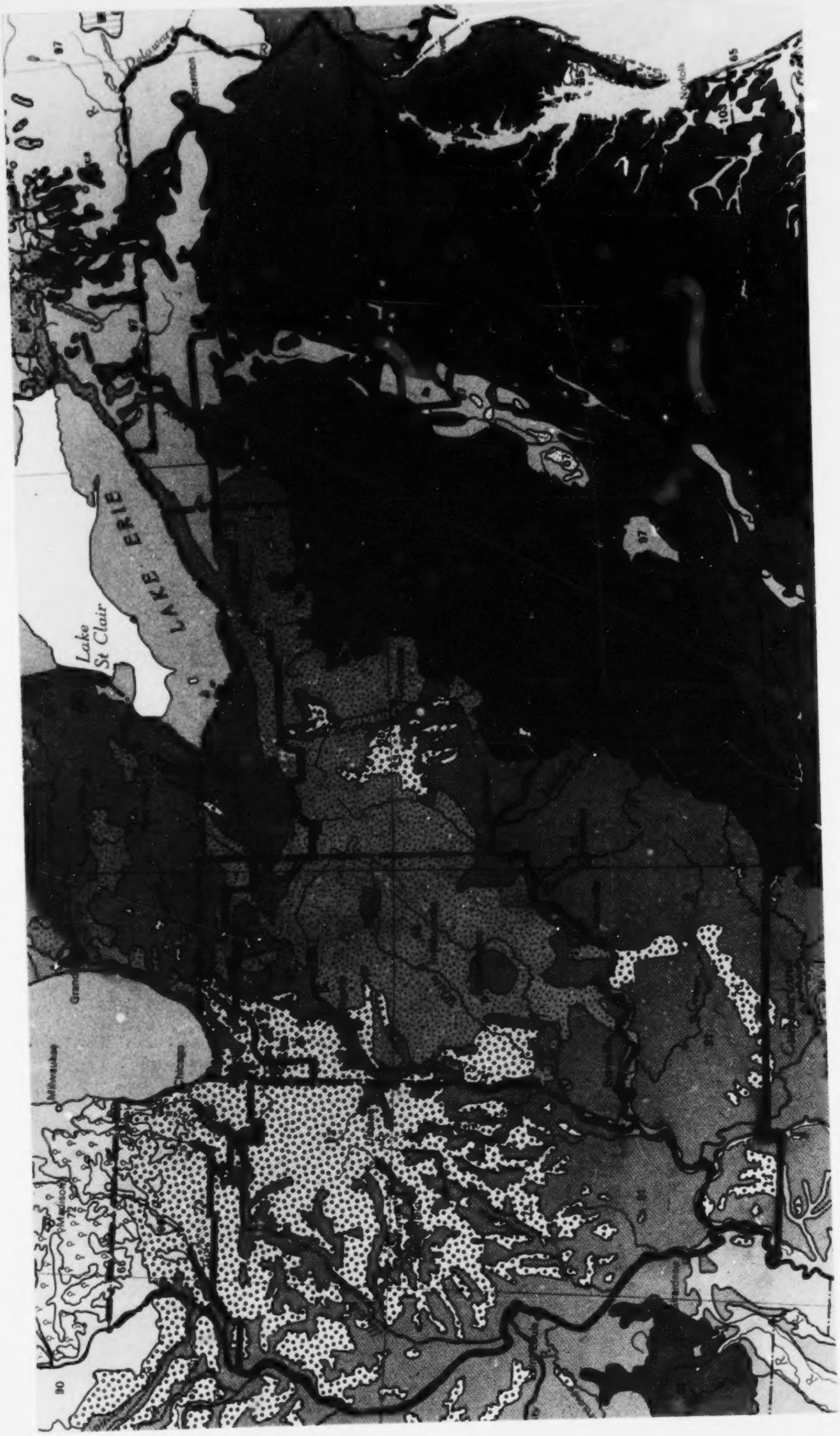
Much is known regarding the status of populations of game animals and furbearers. Knowledge of their life cycles and the quality of available habitats permits inferences to be made as to the general welfare of their populations. More importantly, fish and game authorities monitor abundances of most species on an annual basis through extrapolation from indices of abundance. Also, data are available from the Fur Resources Committee of the International Association of Game, Fish and Conservation Commissioners for fur harvests between 1970 and 1975. The latter set of data is, of course, biased as a population indicator by state and local trapping regulations, species-specific traditional hunting and trapping preferences, and variability across species and years with respect to monetary incentives.

In general, the most widely abundant game species today are those that can inhabit hedgerows and woodlots on farms. Of these, the most common are

Grand
E12-2
Lake St Clair
LAKE ERIE
A7-17
A7-11

	WARM SOILS Mean annual soil temperature higher than about 47°F			COOL SOILS Mean annual soil temperature lower than about 47°	
	MOIST	WET	DRY	MOIST	WET
ALFISOLS	■ Udalfs A6[1] A7[1] A8	■ Aqualfs A1 A2	■ Ustalfs A9 A10 Xeralfs A11 A12 A13	□ Boralfs A3 A4 A5	
ARIDISOLS			■ Argids D1 D2 D3 D4 Orthids D5 D6		
ENTISOLS	■ Psamments Quartzipsamments E10 Udipsamments E12[1]	■ Aquents E1	■ Fluvents E2 Orthents E3 E4 E5 E6 E7 E8 Psamments Torripsamments E11 Ustipsamments E13 Xeropsamments E14	■ Psamments Cryopsamments E9	
HISTOSOLS		■ H2			■ H1
INCEPTISOLS	■ Andepts Dystrandepts I2 Ochrepts Dystrochrepts I8 Eutrochrepts I9 Fragiochrepts I10 Tropepts I12 Umbrepts Haplumbrepts I14	■ Aquepts Haplaquepts I5 Humaquepts I6	■ Andepts Eutrandepts I3 Ochrepts Ustochrepts I11	■ Andepts Cryandepts I1 Ochrepts Cryochrepts I7 Umbrepts Cryumbrepts I13	■ Aquepts Cryaquepts I4
MOLLISOLS	■ Udolls M6 M7 M8	■ Aquolls M1 M2[1]	■ Ustolls M9 M10 M11 M12 M13 M14 Xerolls M15 M16	■ Borolls M3 M4 M5	
OXISOLS	■ Orthox O1		■ Ustox O2		
SPODOSOLS		■ Aquods S1		■ Orthods S2 S3 S4[2]	
ULTISOLS	■ Humults U2 U3 Udults U4 U5 U6	■ Aquults U1	■ Xerults U7		
VERTISOLS	□ Uderts V1 V2		□ Usterts V3 V4 Xererts V5		
Misc land types	■ X2 X4		■ X1 X5	■ X3	

Figure 2-7. Generalized soil map of the ORBES region.



Delaware
Norfolk
LAKE ERIE
Lake St Clair
Milwaukee
Chicago
Madison

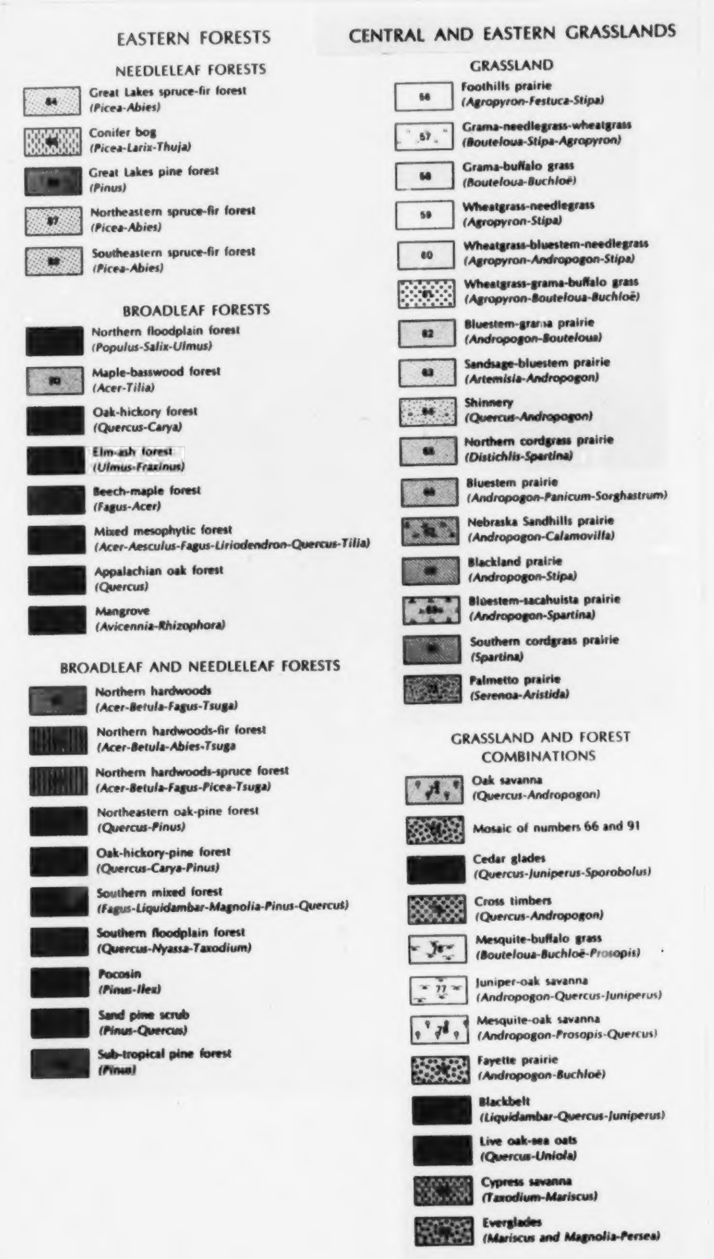
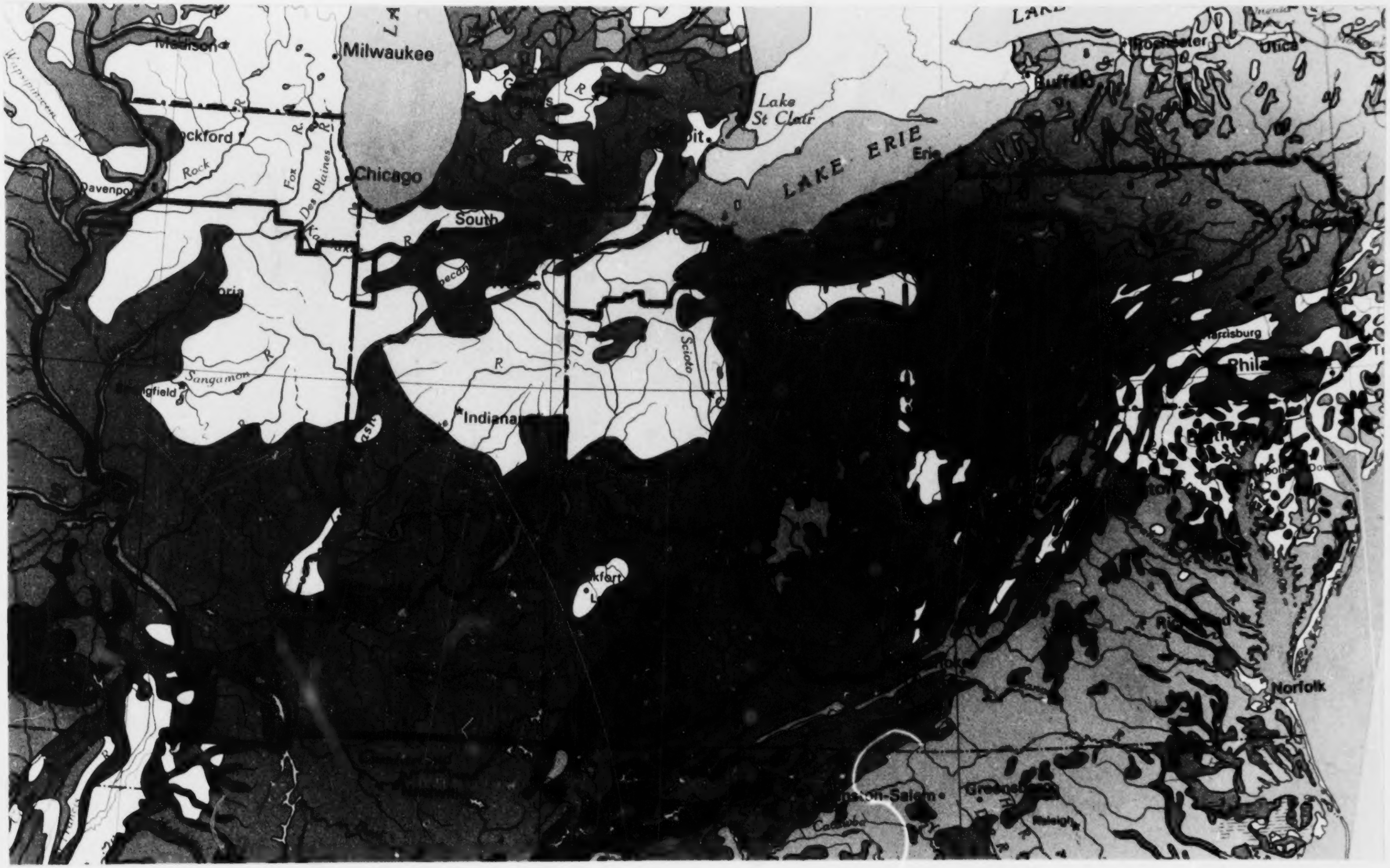

EASTERN FORESTS
NEEDLELEAF FORESTS
Great Lakes spruce-fir forest (Picea-Abies)
Conifer bog (Picea-Larix-Thuja)
Great Lakes pine forest (Pinus)
Northeastern spruce-fir forest (Picea-Abies)
Southeastern spruce-fir forest (Picea-Abies)
BROADLEAF FORESTS
Northern floodplain forest (Populus-Salix-Ulmus)
Maple-basswood forest (Acer-Tilia)
Oak-hickory forest (Quercus-Carya)
Elm-ash forest (Ulmus-Fraxinus)
Beech-maple forest (Fagus-Acer)
Mixed mesophytic forest (Acer-Aesculus-Fagus-Liriodendron-Quercus-Tilia)
Appalachian oak forest (Quercus)
Mangrove (Avicennia-Rhizophora)
BROADLEAF AND NEEDLELEAF FORESTS
Northern hardwoods (Acer-Betula-Fagus-Tsuga)
Northern hardwoods-fir forest (Acer-Betula-Abies-Tsuga
Northern hardwoods-spruce forest (Acer-Betula-Fagus-Picea-Tsuga)
Northeastern oak-pine forest (Quercus-Pinus)
Oak-hickory-pine forest (Quercus-Carya-Pinus)
Southern mixed forest (Fagus-Liquidambar-Magnolia-Pinus-Quercus)
Southern floodplain forest (Quercus-Nyassa-Taxodium)
Pocosin (Pinus-Ilex)
Sand pine scrub (Pinus-Quercus)
Sub-tropical pine forest (Pinus)
CENTRAL AND EASTERN GRASSLANDS
GRASSLAND
Foothills prairie (Agropyron-Festuca-Stipa)
Grama-needlegrass-wheatgrass (Bouteloua-Stipa-Agropyron)
Grama-buffalo grass (Bouteloua-Buchloë)
Wheatgrass-needlegrass (Agropyron-Stipa)
Wheatgrass-bluestem-needlegrass (Agropyron-Andropogon-Stipa)
Wheatgrass-grama-buffalo grass (Agropyron-Bouteloua-Buchloë)
Bluestem-grama prairie (Andropogon-Bouteloua)
Sandsage-bluestem prairie (Artemisia-Andropogon)
Shinnery (Quercus-Andropogon)
Northern cordgrass prairie (Distichlis-Spartina)
Bluestem prairie (Andropogon-Panicum-Sorghastrum)
Nebraska Sandhills prairie (Andropogon-Calamovilfa)
Blackland prairie (Andropogon-Stipa)
Bluestem-sacahuista prairie (Andropogon-Spartina)
Southern cordgrass prairie (Spartina)
Palmetto prairie (Serenoa-Aristida)
GRASSLAND AND FOREST COMBINATIONS
Oak savanna (Quercus-Andropogon)
Mosaic of numbers 66 and 91
Cedar glades (Quercus-Juniperus-Sporobolus)
Cross timbers (Quercus-Andropogon)
Mesquite-buffalo grass (Bouteloua-Buchloë-Prosopis)
Juniper-oak savanna (Andropogon-Quercus-Juniperus)
Mesquite-oak savanna (Andropogon-Prosopis-Quercus)
Fayette prairie (Andropogon-Buchloë)
Blackbelt (Liquidambar-Quercus-Juniperus)
Live oak-sea oats (Quercus-Uniola)
Cypress savanna (Taxodium-Mariscus)
Everglades (Mariscus and Magnolia-Persea)

Figure 2-8. Potential natural vegetation in the ORBES region.


Madison
Milwaukee
Rockford
Rock
Fox
Des Plaines
Chicago
Davenport
South
Sangamon
Springfield
Indiana
Scioto
Lake St Clair
LAKE ERIE
Erie
Buffalo
Rochester
Utica
Harrisburg
Phila
Norfolk
Winston-Salem
Greensboro
Raleigh
Catawba

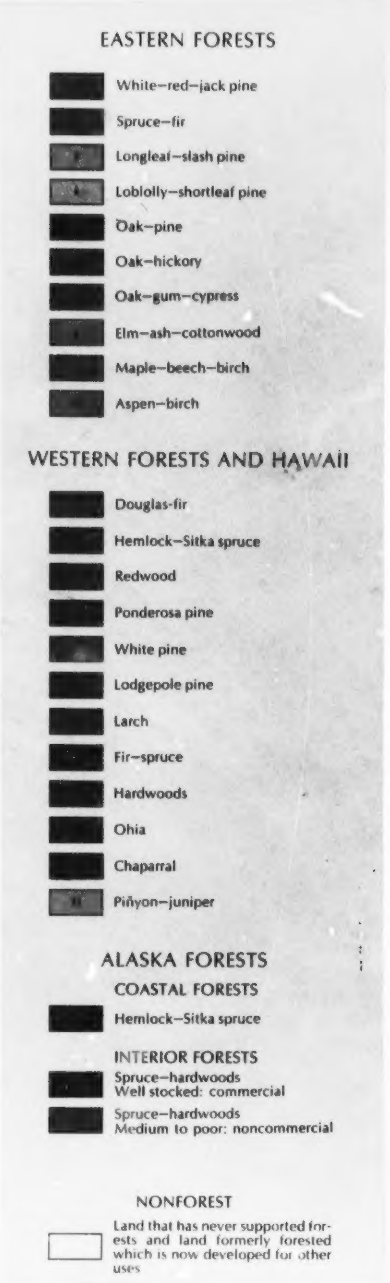

EASTERN FORESTS
White–red–jack pine
Spruce–fir
Longleaf–slash pine
Loblolly–shortleaf pine
Oak–pine
Oak–hickory
Oak–gum–cypress
Elm–ash–cottonwood
Maple–beech–birch
Aspen–birch
WESTERN FORESTS AND HAWAII
Douglas-fir
Hemlock–Sitka spruce
Redwood
Ponderosa pine
White pine
Lodgepole pine
Larch
Fir–spruce
Hardwoods
Ohia
Chaparral
Piñyon–juniper
ALASKA FORESTS
COASTAL FORESTS
Hemlock–Sitka spruce
INTERIOR FORESTS
Spruce–hardwoods Well stocked: commercial
Spruce–hardwoods Medium to poor: noncommercial
NONFOREST
Land that has never supported forests and land formerly forested which is now developed for other uses

Figure 2-9. Forest resources in the ORBES region.

TABLE 2-8. DEFINITIONS OF FOREST TYPES APPEARING IN FIGURE 2-9

Oak-pine.	Forests in which hardwoods (usually upland oaks) comprise a plurality of the cover but in which southern pines comprise 25 to 50% of the cover. (Common associates include gum, hickory, sassafras, and yellow-poplar.)
Oak-hickory.	Forests in which upland oaks or hickory, singly or in combination, comprise a plurality of the cover except where pines comprise 25 to 50%, in which case the stand would be classified oak-pine. (Common associates include yellow-poplar, elm, maple, black walnut, black locust, and catalpa.)
Oak-gum-cypress.	Bottomland forests in which tupelo, blackgum, sweetgum, oaks, or southern cypress, singly or in combination, comprise a plurality of the cover except where pines comprise 25 to 50%, in which case the stand would be classified oak-pine. (Common associates include cottonwood, willow, ash, elm, hackberry, and maple.)
Elm-ash-cottonwood.	Lowland forests in which elm, ash, cottonwood, or soft maple, singly or in combination, comprise a plurality of the cover. (Common associates include willow and sycamore.)
Maple-beech.	Forests in which 50% or more of the cover is maple or beech, singly or in combination, except stands that are classified redcedar-hardwoods or oak-pine.

cottontail rabbit and bobwhite quail, followed by fox squirrel, raccoon, woodchuck, red fox, striped skunk, and opossum. Raccoon comprise about 25 percent of the fur harvest, several hundred thousand having been taken annually between 1970 and 1975 in Indiana, Kentucky, and Ohio. While the opossum is another furbearer, it varies in importance over the ORBES region, constituting 2 to 6 percent of the fur harvest in Ohio and Indiana and 8 to 18 percent in Kentucky; this illustrates the opossum's preference for more southern climes. The red fox is a furbearer of lesser importance; it is further discussed below in relation to the gray fox. The striped skunk is of little importance as a furbearer; it lives only in those forest-edge environments near water.

Several game birds are common in farmlands. The ring-necked pheasant, for example, is popular with hunters in Indiana, Ohio, and Pennsylvania. Other birds not subjected to sport hunting that have prospered in agricultural areas in recent years include starling, red-winged blackbird, brown-headed cowbird, and common grackle. The first three species are now so abundant in the ORBES region that they comprise a widely known nuisance to humans during the winter flocking period in southern Kentucky.

Game species needing more woodland than those mentioned above include white-tailed deer, gray squirrel, turkey, and gray fox. White-tailed deer are most abundant in the Ohio coal counties throughout southern and northeastern Indiana, most of Kentucky and West Virginia, and western Pennsylvania. Gray squirrel are scarce in western Indiana and Illinois but plentiful in large wooded tracts in the rest of the ORBES region. Gray squirrels are the most hunted game species in West Virginia. Gray squirrels inhabit primarily extensive hardwood forests with mast-producing trees, characteristic of much of the Appalachian Plateau. Wild turkey were extinct in Indiana and Ohio in the early twentieth century. Populations and distributions of turkeys today reflect programs to re-establish the species as a free-ranging resident. Large populations of turkey occur in extensive tracts of government-protected forests in Perry and Clark counties in Indiana and in Hocking, Vinton, and Athens counties in Ohio, though turkey are now also spreading throughout the Ohio coal region. The turkey ranks as one of the six most hunted game species in West Virginia. West Virginia and Pennsylvania lead the northeastern states in turkey populations, with West Virginia having the tenth largest turkey population in the nation.

The gray fox is a furbearer of relatively minor importance. It is taken about as often as the red fox in Indiana and Ohio but about twice as often as the red fox in Kentucky, despite the fact that the gray fox's pelt is worth only about half as much as the red's. Unlike the red fox, which is adapted to agricultural areas, the gray fox prefers the woodlands and rimrock country remote from humans and are more common in the southern portions of the ORBES region. The gray fox populations and the ongoing expansion of the turkey populations are both indicators of the rural nature of much of the ORBES region today.

Muskrat, beaver, and mink require aquatic habitats. Muskrat occur almost anywhere that permanent marsh, ditch, or stream water is available. They are prolific breeders and can develop large populations rapidly. Muskrat are the most important furbearers in the region, with a combined total of over one million taken each year in Ohio, Indiana and Kentucky. The apparently greater abundance of muskrat in Ohio and Indiana may be due to the greater prevalence of marsh habitats in the northern portions of those states. The beaver was nearly exterminated in the ORBES region but is now widely dispersed, though still not plentiful. Mink populations are not very well monitored but may be expected along small, clean streams. Mink are generally of relatively minor importance as furbearers with respect to numbers taken.

Among waterfowl, mallard and wood duck are common. In Ohio, hunter harvest surveys taken at the county level reveal that the most common dabblers taken are, in descending order, wood duck, mallard, black duck, green-winged teal, and blue-winged teal, while the most common divers are ring-necks, followed by lesser scaup. The Pennsylvania ORBES region is located on a major waterfowl migration route that is part of the Atlantic flyway. Consequently, the rivers of the area occasionally serve as resting places for migrating species such as the ring-necked duck, greater scaup, golden-eye, buffle-head, mallard, oldsquaw, and common merganser. Ducks breeding in this area include the mallard, wood duck, and black duck.

Other wetland migratory game birds of lower density or hunter preference are coots, sora rails, Virginia rails, Wilson's snipe, woodcock, and common gallinules.

While generally more numerous than many game species, data describing distributions and abundances of non-game species are usually very sparse. Songbirds comprise the largest group of terrestrial vertebrates in the ORBES region. Strictly woodland species have experienced population decreases over the years due to the clearing of mature forests. Conversely, populations of species preferring second growth woodland and thickets, suburban yards and gardens, and agricultural areas have increased.

Terrestrial Ecosystem Assessment Variables

County-level data for four-terrestrial ecosystem variables, for which a somewhat homogeneous data base exists, were collected as baseline data for assessing terrestrial ecosystem impacts. These variables include: class I and II soils, forest lands, natural areas, and endangered species. Tables 2-9 through 2-14 present data for these variables for all ORBES region counties. Table 2-15 summarizes these data for ORBES state portions. Values for each variable were indexed according to units ranging in value from 1 (low) to 10 (high) according to the indices presented in Table 2-16. The units were then used in the terrestrial ecosystem assessment model discussed in detail in Section 5.3.

Soil Productivity--

The development of new energy facilities in the ORBES region will involve major land use conversions and will subsequently result in some loss of productive soils. The magnitude of impacts to ecological systems will vary according to the soil productivity lost. A good assessment of productive soils in the ORBES region can be made by considering the soil capability classes defined and inventoried in the soil and water conservation needs inventories for the six ORBES states (see Purdue University Cooperative Extension Service (1968) for an example).

TABLE 2-9. ILLINOIS TERRESTRIAL ECOSYSTEM BASELINE DATA

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species	
		Acres	%	Units	Acres	%	Units	#(Ni)	(Uc)	Total	Units	# Per County	Units
Adams	554,240	303,533	55	6	61,700	11	2	2 3 11	3 2 1	23	9	7-10	5
Alexander	143,400	29,102	20	2	43,100	30	3	2 12 8	3 2 1	38	10	>20	10
Bond	245,120	129,888	53	6	35,700	15	2	2	1	2	1	1-3	1
Brown	196,480	96,513	49	5	38,200	19	2	1 4	2 1	6	2	1-3	1
Bureau	555,520	454,296	82	9	25,600	5	1	1 6 2	3 2 1	17	6	1-3	1
Calhoun	165,650	46,759	28	3	57,700	35	4	3 12	2 1	18	7	11-15	7
Cass	236,800	127,189	54	6	32,000	14	2	4 4	2 1	12	4	7-10	5
Champaign	640,000	583,242	91	10	7,100	1	1	2 5	3 2	16	6	1-3	1
Cnristian	453,568	379,349	84	9	16,466	4	1	1	1	1	0	1-3	1
Clark	323,200	163,824	51	6	48,000	15	2	1 1 4	3 2 1	9	3	4-6	3
Clay	296,960	115,874	39	4	47,100	16	2	2 1	2 1	5	1	1-3	1
Clinton	298,694	101,637	34	4	30,990	10	1	1 2	2 1	4	1	1-3	1
Coles	324,400	261,374	81	9	24,084	7	1	12 3	2 1	27	10	4-6	3
Crawford	282,800	135,577	48	5	47,400	17	2	3 1	2 2	8	3	4-6	3
Cumberland	221,440	124,829	56	6	24,483	11	2	1 1	2 1	3	1	1-3	1
DeWitt	255,360	217,947	85	9	9,200	4	1	1	1	1	0	0	0
Douglas	268,740	249,367	93	10	4,700	2	1	2	1	2	0	1-3	1
Edgar	401,920	360,976	90	9	20,312	5	1	1 1	2 1	3	1	4-6	3
Edwarus	144,000	74,526	52	4	21,465	15	2	1	2	2	0	4-6	3
Effingham	309,480	109,772	35	4	54,500	18	2	1 3 2	3 2 1	11	4	4-6	3
Fayette	458,730	222,414	48	5	91,500	20	2	7 6	2 1	20	7	1-3	1
Ford	312,320	265,348	85	9	1,254	1	1	1 2 1	3 2 1	8	3	0	0
Franklin	277,760	101,483	37	4	40,119	14	2	2 1	2 1	5	1	1-3	1
Fulton	559,360	364,145	62	7	96,338	17	2	8	1	8	3	4-6	3

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Table 2-9 Continued

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species	
		Acres	%	Units	Acres	%	Units	$F(N_i)$	(U_c)	Total	Units	# Per County	Units
Gallatin	209,900	122,369	58	6	45,700	22	3	3 1	2 1	7	2	4-6	3
Greene	347,520	224,275	65	7	55,962	16	2	2 2	2 1	6	2	4-6	3
Grundy	275,980	224,669	81	9	11,050	4	1	1 2 6	3 2 1	13	5	4-6	3
Hamilton	278,400	101,966	37	4	48,713	17	2	0	--	0	0	1-3	1
Hancock	510,140	355,819	70	7	73,900	14	2	1 1	3 2	13	5	4-6	3
Hardin	117,120	20,047	17	2	44,117	38	4	4 13 6	3 2 1	44	10	7-10	5
Henderson	243,840	128,688	53	6	41,256	17	2	3 9	2 1	15	5	4-6	3
Henry	528,640	340,104	64	7	11,500	2	1	4 2	2 1	10	3	1-3	1
Iroquois	718,080	580,379	81	9	13,600	2	1	1 6	3 2	15	5	1-3	1
Jackson	385,800	77,784	20	2	113,218	29	3	3 25 6	3 2 1	65	10	16-20	9
Jasper	316,8-0	121,604	38	4	44,287	14	2	2 2 2	3 2 1	12	4	4-6	3
Jefferson	367,360	118,016	32	4	44,528	12	2	3 2	2 1	8	3	1-3	1
Jersey	239,362	130,411	54	6	52,615	22	3	2 8	2 1	12	4	7-10	5
Johnson	219,500	42,825	20	2	75,600	34	4	2 27 3	3 2 1	63	10	7-10	5
Kankakee	434,700	310,307	71	8	21,625	5	1	1 7 12	3 2 1	29	10	4-6	3
Knox	465,920	290,122	62	7	46,500	10	1	2 3	2 1	7	2	1-3	1
LaSalle	737,920	619,417	84	9	31,521	4	1	1 6 11	3 2 1	26	10	1-3	1
Lawrence	239,360	139,040	58	6	34,000	14	2	1 4	3 1	7	2	7-10	5
Livingston	667,520	579,979	87	9	11,000	2	1	2 1	2 1	5	1	0	0
Logan	398,080	365,005	92	10	9,400	2	1	4 1	2 1	9	3	0	0
McDonough	372,480	303,987	82	9	26,200	7	1	4	1	4	1	0	0
McLean	750,720	689,510	92	10	6,467	1	1	2 3 2	3 2 1	14	5	1-3	1
Macon	368,640	311,328	84	9	7,490	2	1	5 3	2 1	13	5	0	0

Table 2-9 Continued

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species	
		Acres	%	Units	Acres	%	Units	#(Ni)	(U$_c$)	Total	Units	# Per County	Units
Macoupin	558,080	382,710	69	7	75,400	14	2	1 4 6	3 2 1	17	6	1-3	1
Madison	467,840	257,741	55	6	54,200	12	2	4 3	2 1	11	4	7-10	5
Marion	370,615	108,224	29	3	72,969	20	2	1 3 4	3 2 1	13	5	4-6	3
Marshall	252,800	209,005	83	9	23,400	9	1	3 2	2 1	8	3	0	0
Mason	346,240	153,574	44	5	40,000	12	2	3 13 12	3 2 1	47	10	7-10	5
Massac	157,440	47,661	30	3	32,622	21	3	1 14 3	3 2 1	34	10	11-15	7
Menard	199,680	151,171	76	8	14,400	7	1	1 3	2 1	5	1	0	0
Mercer	355,840	221,566	62	7	24,300	7	1	2 2	2 1	6	2	4-6	3
Monroe	243,200	95,579	39	4	60,000	25	3	6 13 1	3 2 1	45	10	11-15	7
Montgomery	449,075	325,179	72	8	48,100	11	2	2 2	2 1	6	2	1-3	1
Morgan	361,600	262,650	73	8	26,100	7	1	2	2	4	1	4-6	3
Moultrie	220,800	195,788	89	9	4,250	2	1	1	2	2	0	1-3	1
Peoria	399,360	239,032	60	6	39,200	10	1	5 11	2 1	21	8	1-3	1
Perry	283,500	51,677	18	2	35,697	13	2	5 2	2 1	12	4	4-6	3
Piatt	279,680	252,602	90	9	7,000	3	1	1 1	3 2	5	1	0	0
Pike	530,560	305,739	58	6	85,800	16	2	1 3 19	3 2 1	28	10	7-10	5
Pope	243,840	36,137	15	2	61,072	25	3	7 36 4	3 2 1	97	10	7-10	5
Pulaski	130,600	35,510	27	3	28,600	22	3	1 4 4	3 2 1	15	5	7-10	5
Putnam	106,240	68,250	64	7	13,738	13	2	4 1	2 1	9	3	0	0
Randolph	380,100	136,536	36	4	59,808	16	2	1 7 4	3 2 1	21	8	16-20	9
Richland	232,960	93,917	40	4	26,746	11	2	2	2	4	1	4-6	3
St. Clair	428,800	191,334	45	5	58,300	14	2	2 17 3	3 2 1	43	10	7-10	5
Saline	245,760	101,229	41	5	34,900	14	2	1 4 4	3 2 1	15	5	1-3	1

Table 2-9 Continued

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species	
		Acres	%	Units	Acres	%	Units	#(N_i)	(U_c)	Total	Units	# Per County	Units
Sangamon	563,200	433,902	77	8	37,195	7	1	3 1	2 1	7	2	1-3	1
Schuyler	277,760	144,889	52	6	76,700	28	3	3	1	3	1	1-3	1
Scott	160,640	92,796	58	6	15,100	9	1	1	2	2	0	4-6	3
Shelby	494,080	344,081	70	7	45,177	0	1	1	2	2	10	4-6	3
Stark	186,240	145,363	78	8	5,000	3	1	0	--	0	10	1-3	1
Tazewell	417,920	294,538	70	7	28,400	7	1	3 10	2 1	16	6	4-6	3
Union	264,900	76,593	29	3	76,400	29	3	1 12 10	3 2 1	37	10	16-20	9
Vermilion	574,720	459,808	80	8	33,543	6	1	1 11 3	3 2 1	28	10	4-6	3
Wabash	141,440	92,535	65	7	9,215	7	1	1 2 1	3 2 1	8	3	7-10	5
Warren	346,880	281,755	81	9	19,600	6	1	2 1	2 1	5	1	0	0
Washington	361,265	111,835	31	4	57,218	16	2	1 4 2	3 2 1	13	5	1-3	1
Wayne	457,600	156,950	34	4	67,850	15	2	3	1	3	1	1-3	1
White	320,640	174,594	54	6	30,700	11	2	0	--	0	0	4-6	3
Williamson	271,900	69,787	26	3	68,900	25	3	1 12 1	3 2 1	28	10	4-6	3
Woodford	343,680	270,513	79	8	22,600	7	1	1 7	3 1	10	3	1-3	1

[1] U_c = uniqueness coefficient where: 1 = normal
2 = medium
3 = high

N_i = number of natural areas in each uniqueness category

Sources: (Ackerman 1975; Evers et al. 1977; Illinois Department of Conservation 1978b; Illinois Nature Preserve Commission 1977; University of Illinois Cooperative Extension Service 1970.)

TABLE 2-10. INDIANA TERRESTRIAL ECOSYSTEM BASELINE DATA

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species	
		Acres	%	Units	Acres	%	Units	#(Ui)	(U_c)	Total	Units	# Per County	Units
Adams	220,700	204,532	93	10	15,000	7	1	0	--	0	0	3	1
Allen	428,800	305,879	71	8	35,237	8	1	1 2	3 1	5	1	4	3
Bartholomew	256,600	171,061	67	7	34,886	14	2	0	--	0	0	6	3
Benton	261,700	242,589	93	10	2,000	1	1	0	--	0	0	4	3
Blackford	106,800	97,209	91	10	10,849	10	1	0	--	0	0	3	1
Boone	273,280	250,183	92	10	11,407	4	1	0	--	0	0	4	3
Brown	206,400	28,636	14	2	135,140	65	7	1 1	2 1	3	1	6	3
Carroll	239,300	199,621	83	9	16,289	7	1	1	1	1	0	9	5
Cass	265,600	215,113	81	9	18,981	7	1	1	1	1	0	7	5
Clark	245,500	102,897	42	5	90,083	37	4	1	2	2	0	7	5
Clay	232,960	53,264	23	3	47,933	21	3	0	--	0	0	8	5
Clinton	260,500	241,444	93	10	9,665	4	1	1	2	2	0	4	3
Crawford	199,700	27,651	14	2	97,454	49	5	1 6	2 1	8	3	9	5
Daviess	275,600	157,128	57	6	38,643	14	2	1	1	1	0	10	5
Dearborn	195,800	57,891	30	3	44,540	23	3	1	1	1	0	6	3
Decatur	236,550	165,513	70	7	23,537	10	1	0	--	0	0	6	3
Delaware	253,500	179,357	71	8	11,534	5	1	3	1	3	1	4	3
Dubois	276,800	86,785	31	4	88,695	32	4	1	1	1	0	10	5
Fayette	137,600	93,888	68	7	19,001	14	2	1 2	3 1	5	1	4	3
Floyd	95,300	24,473	26	3	37,182	39	4	0	--	0	0	7	5
Fountain	254,080	194,292	76	8	27,446	11	2	2 1	2 1	5	1	11	7
Franklin	252,100	95,045	38	4	60,000	24	3	0	--	0	0	5	3
Fulton	234,900	140,411	60	6	14,472	6	1	0	--	0	0	4	3
Gibson	319,300	200,260	63	7	45,060	14	2	1 1	2 1	3	1	13	7
Grant	269,500	175,687	65	7	14,123	5	1	1	1	1	0	3	1
Greene	351,300	141,487	40	4	100,253	29	3	0	--	0	0	9	5
Hamilton	256,500	214,270	84	9	13,239	5	1	1	2	2	0	4	3
Hancock	195,200	169,582	87	9	8,469	4	1	0	--	0	0	5	3
Harrison	306,500	56,131	18	2	131,490	43	5	1 3 3	3 2 1	12	4	9	5
Hendricks	266,900	216,620	81	9	17,000	6	1	0	--	0	0	5	3
Henry	256,000	196,033	77	8	17,111	7	1	0	--	0	0	4	3
Howard	187,000	169,456	91	10	7,000	4	1	1	1	1	0	3	3
Huntington	249,600	197,270	79	8	20,430	8	1	2	1	2	0	4	3
Jackson	332,800	146,555	44	5	110,323	33	4	1	2	2	0	8	5

Table 2-10 Continued

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species	
		Acres	%	Units	Acres	%	Units	#(NI)	(U_C)	Total	Units	# Per County	Units
Jasper	359,100	131,723	37	4	25,613	7	1	1 1	2 1	3	1	3	1
Jay	247,000	226,588	92	10	19,450	8	1	1	1	1	0	3	1
Jefferson	234,300	88,646	38	4	63,436	27	3	1	2	2	0	7	5
Jennings	241,200	112,236	47	5	69,878	29	3	4	1	4	1	6	3
Johnson	201,240	148,648	74	8	8,488	4	1	0	--	0	0	6	3
Knox	330,900	215,884	65	7	38,721	12	2	2	1	2	0	14	7
Kosciusko	334,300	229,050	69	7	28,047	8	1	1 2	2 1	4	1	3	1
Lawrence	293,760	76,808	26	3	117,416	40	4	1 2	2 1	3	1	9	5
Madison	289,850	249,898	86	9	15,875	5	1	0	--	0	0	4	3
Marion	257,300	92,849	36	4	12,407	5	1	0	--	0	0	6	3
Marshall	284,120	175,760	62	7	26,678	9	1	0	--	0	0	3	1
Martin	220,800	48,509	22	3	72,996	33	4	1	1	1	0	10	5
Miami	243,200	174,152	72	8	18,119	7	1	0	--	0	0	5	3
Monroe	246,400	46,599	19	2	110,000	45	5	1 2	2 1	4	1	7	5
Montgomery	324,330	260,430	80	8	24,000	7	1	1 1 4	3 2 1	9	3	5	3
Morgan	259,700	125,184	48	5	92,392	36	4	1 1	2 1	3	1	6	3
Noble	262,400	125,483	48	5	25,524	10	1	2 4	2 1	6	2	3	1
Ohio	55,680	15,683	29	3	14,567	27	3	0	--	0	0	7	5
Orange	259,059	55,195	21	3	102,770	40	4	1	2	2	0	9	5
Owen	246,400	63,689	26	3	115,000	47	5	2 2	2 1	6	2	8	5
Parke	286,570	172,274	60	6	86,595	30	3	3 2	2 1	8	3	10	5
Perry	245,760	52,944	22	3	94,300	38	4	1	1	1	0	8	5
Pike	214,400	101,854	48	5	77,951	36	4	0	--	0	0	10	5
Posey	264,900	166,007	63	7	32,973	12	2	4	1	4	1	13	7
Pulaski	277,100	80,685	29	3	32,000	12	2	1	2	2	0	4	3
Putnam	312,320	148,179	47	5	72,000	23	3	5	1	5	1	4	3
Randolph	292,500	260,150	89	9	13,226	5	1	1 1	2 1	3	1	4	3
Ripley	282,600	101,530	36	4	55,525	20	2	2 4	2 1	8	3	5	3
Rush	261,700	242,288	93	10	12,851	5	1	0	--	0	0	4	3
Scott	123,400	71,785	58	6	43,592	35	4	0	--	0	0	7	5
Shelby	261,760	224,614	86	9	7,607	3	1	1	2	2	0	6	3

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Table 2-10 Continued

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species	
		Acres	%	Units	Acres	%	Units	#(N_i)	(U_c)	Total	Units	# Per County	Units
Spencer	253,400	132,541	52	6	69,780	28	3	1	2	2	0	7	5
Starke	199,000	26,665	13	2	27,000	14	2	0	--	0	0	3	1
Sullivan	292,500	135,521	46	5	54,791	19	2	0	--	0	0	12	7
Switzerland	141,440	35,323	25	3	36,490	26	3	0	--	0	0	8	5
Tippecanoe	320,600	255,648	80	8	24,571	8	1	2	1	2	0	11	7
Tipton	167,000	158,692	95	10	10,000	6	1	0	--	0	0	4	3
Union	107,080	77,554	72	8	15,000	14	2	1	2	2	0	4	3
Vanderburgh	154,200	83,460	54	6	18,736	12	2	1 2	2 1	4	1	8	5
Vermillion	168,300	119,886	71	8	30,346	18	2	1	1	1	0	11	7
Vigo	265,600	143,538	54	6	45,000	17	2	1 2	2 1	4	1	12	7
Wabash	269,400	196,664	73	8	20,552	8	1	6	1	6	2	3	1
Warren	235,500	188,150	80	8	23,350	10	1	4	1	4	1	10	5
Warrick	249,700	106,750	43	5	72,479	29	3	0	--	0	0	6	3
Washington	330,120	123,176	37	4	130,891	40	4	2	1	2	0	8	5
Wayne	258,900	188,906	73	8	23,000	9	1	5	1	5	1	4	3
Wells	235,500	211,200	90	9	17,333	7	1	1 1	2 1	3	1	4	3
White	318,000	213,647	67	7	12,807	4	1	0	--	0	0	9	5
Whitley	215,000	137,116	64	7	20,102	9	1	1	1	1	0	4	3

[1] U_c = uniqueness coefficient where:
1 = normal
2 = medium
3 = high

N_i = number of natural areas in each uniqueness category

Sources: (Barnes undated; Indiana Department of Natural Resources 1978; Indiana Department of Natural Resources undated; Indiana University, The Ohio State University and Purdue University 1977; Lindsey et al. 1969; Purdue University Cooperative Extension Service 1968.)

TABLE 2-11. KENTUCKY TERRESTRIAL ECOSYSTEM BASELINE DATA

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species	
		Acres	%	Units	Acres	%	Units	#(Ni)	(U_c)	Total	Units	# Per County	Units
Adair	251,510	41,484	16	2	108,880	43	5	1	1	1	0	3	1
Allen	232,960	21,694	9	1	83,800	36	4	0	--	0	0	2	1
Anderson	131,840	12,869	8	1	34,100	26	3	1	1	1	0	1	1
Ballard	165,760	74,382	45	5	36,793	22	3	0	--	0	0	12	7
Barren	311,040	135,760	44	5	72,131	23	3	1	1	1	0	7	5
Bath	183,680	35,180	19	2	42,543	23	3	0	--	0	0	1	1
Bell	236,000	4,956	2	1	202,171	85	9	2	1	2	0	7	5
Boone	151,280	19,206	12	2	44,400	27	3	1 3	2 1	5	1	3	1
Bourbon	192,000	71,056	37	4	5,100	3	1	0	--	0	0	1	1
Boyd	102,400	7,366	7	1	57,200	56	6	0	--	0	0	1	1
Boyle	117,120	36,562	31	4	20,100	17	2	1	1	1	0	2	1
Bracken	130,560	12,389	9	1	39,600	30	3	0	--	0	0	1	1
Breathitt	361,160	11,270	3	1	279,585	77	8	0	--	0	0	5	3
Breckinridge	360,960	39,609	24	3	160,000	44	5	0	--	0	0	5	3
Bullitt	192,000	39,987	20	2	74,600	39	4	0	--	0	0	11	7
Butler	283,520	74,029	26	3	135,500	48	5	0	--	0	0	4	3
Caldwell	228,480	113,230	50	5	79,200	35	4	1	1	1	0	5	3
Calloway	245,760	103,656	42	5	77,100	31	4	0	--	0	0	14	7
Campbell	95,360	8,067	8	1	18,800	18	2	2	1	2	0	2	1
Carlisle	124,800	62,056	50	5	42,400	34	4	0	--	0	0	11	7
Carroll	83,200	17,337	20	2	26,600	32	4	1	1	1	0	2	1
Carter	257,380	16,451	6	1	181,900	70	7	1	1	1	0	4	3
Casey	278,400	55,303	20	2	153,800	55	6	1	1	1	0	2	1
Christian	464,640	221,673	48	5	131,400	28	3	0	--	0	0	5	3
Clark	165,760	57,222	35	4	12,200	7	1	0	--	0	0	2	1
Clay	303,360	18,883	6	1	247,600	82	9	0	--	0	0	1	1
Clinton	121,600	17,873	15	2	61,209	50	5	0	--	0	0	3	1
Crittenden	233,600	92,242	39	4	87,800	37	4	0	--	0	0	7	5
Cumberland	198,400	23,708	12	2	117,656	59	6	0	--	0	0	4	3
Daviess	295,680	128,752	44	5	66,200	22	3	1	1	1	0	6	3
Edmonson	194,560	33,989	17	2	67,796	35	4	1 2	2 1	4	1	19	9
Elliott	153,600	8,776	6	1	114,100	74	8	0	--	0	0	4	3
Estill	166,400	20,777	12	2	117,982	71	8	0	--	0	0	5	3
Fayette	179,200	81,821	46	5	5,500	3	1	2	1	2	0	6	3
Fleming	224,000	42,448	19	2	60,300	27	3	1	1	1	0	2	1

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Table 2-11 Continued

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species	
		Acres	%	Units	Acres	%	Units	#(NI)	(U_c)	Total	Units	# Per County	Units
Floyd	255,360	6,645	3	1	192,600	75	8	0	--	0	0	2	1
Franklin	135,040	29,721	22	3	44,700	33	4	1	--	1	0	6	3
Fulton	129,920	73,716	57	6	32,300	25	3	0	--	0	0	12	7
Gallatin	64,000	7,326	11	2	19,600	30	3	0	--	0	0	2	1
Garrard	151,040	21,489	14	2	23,800	16	2	1	1	1	0	2	1
Grant	159,360	10,496	6	1	38,400	24	3	0	--	0	0	1	1
Graves	358,400	192,587	54	6	80,200	22	3	0	--	0	0	10	5
Grayson	327,680	89,877	27	3	115,760	35	4	2	1	2	0	3	1
Green	180,480	58,956	33	4	60,200	33	4	0	--	0	0	2	1
Greenup	224,640	20,268	9	1	158,000	70	7	0	--	0	0	2	1
Hancock	119,680	33,888	28	3	56,800	47	5	0	--	0	0	4	3
Hardin	394,240	129,065	33	4	100,000	25	3	1	1	1	0	4	3
Harlan	300,160	7,417	2	1	260,600	87	9	1	1	1	0	9	5
Harrison	197,120	51,087	26	3	33,500	17	2	1	1	1	0	1	1
Hart	272,000	48,830	18	2	107,705	39	4	0	--	0	0	6	3
Henderson	277,120	164,482	59	6	61,300	22	3	1	2	2	0	9	5
Henry	184,960	53,529	29	3	44,800	24	3	0	--	0	0	2	1
Hickman	157,440	81,108	51	6	37,900	24	3	0	--	0	0	1	7
Hopkins	353,920	117,500	33	4	160,332	45	5	1	2	2	0	8	5
Jackson	215,680	8,828	4	1	109,273	50	5	0	--	0	0	3	1
Jefferson	240,000	78,629	33	4	33,500	14	2	2	1	2	0	16	9
Jessamine	113,280	34,943	31	4	12,200	11	2	3	1	3	1	3	1
Johnson	168,960	6,851	4	1	136,900	81	9	0	--	0	0	1	1
Kenton	105,600	9,725	9	1	28,200	27	3	0	--	0	0	2	1
Knott	227,840	6,100	3	1	197,600	87	9	0	--	0	0	1	1
Knox	238,720	31,914	13	2	177,700	74	8	0	--	0	0	2	1
Larue	166,400	72,728	44	5	55,700	33	4	0	--	0	0	2	1
Laurel	285,440	37,024	13	2	140,867	49	5	0	--	0	0	6	3
Lawrence	272,000	12,640	5	1	222,800	82	9	0	--	0	0	1	1
Lee	134,400	4,311	3	1	102,312	76	8	0	--	0	0	3	1
Leslie	263,680	6,911	3	1	228,500	86	9	0	--	0	0	2	1
Letcher	216,960	3,802	2	1	186,939	86	9	0	--	0	0	2	1
Lewis	311,040	20,252	6	1	238,578	76	8	1	1	1	0	2	1
Lincoln	217,600	62,056	28	3	58,700	27	3	0	--	0	0	2	1
Livingston	199,680	60,730	30	3	73,300	37	4	0	--	0	0	6	3
Logan	360,320	173,360	48	5	109,700	30	3	2	1	2	0	5	3
Lyon	161,920	26,124	16	2	28,222	17	2	0	--	0	0	13	7
McCracken	160,000	48,068	30	3	37,600	23	3	0	--	0	0	10	5

Table 2-11 Continued

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species	
		Acres	%	Units	Acres	%	Units	# (Ni)	(U_c)	Total	Units	# Per County	Units
McCreary	267,520	8,383	3	1	92,838	35	4	0	--	0	0	9	5
McLean	164,480	53,748	33	4	45,500	28	3	0	--	0	0	4	3
Madison	285,440	58,337	20	2	49,200	17	2	2	1	2	0	2	1
Magoffin	193,920	11,462	6	1	161,000	83	9	0	--	0	0	1	1
Marion	219,520	55,956	25	3	82,800	37	4	0	--	0	0	2	1
Marshall	193,920	75,058	39	4	66,100	34	4	0	--	0	0	19	9
Martin	147,840	5,172	3	1	130,100	88	9	0	--	0	0	1	1
Mason	152,320	35,741	23	3	18,500	12	2	0	--	0	0	1	1
Meade	195,200	46,654	24	3	75,800	39	4	0	--	0	0	14	7
Menifee	134,401	8,922	7	1	79,387	59	6	1	1	1	0	2	1
Mercer	163,840	41,388	25	3	17,600	10	1	0	--	0	0	1	1
Metcalfe	189,440	51,883	27	3	88,000	46	5	0	--	0	0	2	1
Monroe	213,760	51,626	24	3	99,000	46	5	1	1	1	0	3	1
Montgomery	130,560	35,066	27	3	18,700	14	2	0	--	0	0	2	1
Morgan	236,160	18,740	8	1	165,470	70	7	0	--	0	0	1	1
Muhlenberg	307,840	102,065	33	4	140,900	45	5	0	--	0	0	8	5
Nelson	279,680	73,646	26	3	117,200	42	5	0	--	0	0	2	1
Nicholas	130,560	14,207	11	2	23,900	18	2	0	--	0	0	2	1
Ohio	381,440	125,843	33	4	195,800	51	6	0	--	0	0	7	5
Oldham	117,760	45,097	38	4	22,200	19	2	1	1	1	0	2	1
Owen	224,640	17,425	7	1	81,000	36	4	0	--	0	0	3	1
Owsley	126,080	7,114	6	1	92,799	73	8	0	--	0	0	2	1
Pendleton	178,560	18,210	10	1	50,500	28	3	0	--	0	0	1	1
Perry	219,520	3,296	2	1	187,200	85	9	0	--	0	0	1	1
Pike	503,040	9,791	2	1	425,173	84	9	0	--	0	0	1	1
Powell	110,720	8,347	7	1	69,969	63	7	2	2	4	1	6	3
Pulaski	418,560	71,340	17	2	178,420	42	5	1	1	1	0	4	3
Robertson	64,640	7,064	11	2	16,300	25	3	0	--	0	0	2	1
Rockcastle	199,040	33,475	17	2	129,128	65	7	5	1	5	1	3	1
Rowan	185,600	17,433	9	1	92,555	50	5	0	--	0	0	4	3
Russell	152,320	27,289	18	2	62,563	41	5	1	1	1	0	2	1
Scott	181,760	49,206	27	3	25,600	14	2	0	--	0	0	1	1
Shelby	245,120	93,988	38	4	31,400	13	2	1	1	1	0	2	1
Simpson	152,960	85,692	56	6	23,300	15	2	1	1	1	0	4	3
Spencer	123,520	20,158	16	2	24,500	20	2	0	--	0	0	2	1
Taylor	181,760	51,910	34	4	65,800	36	4	1	1	1	0	3	1
Todd	240,640	125,043	51	6	61,700	26	3	1	1	1	0	6	3
Trigg	293,760	53,123	18	2	52,587	18	2	0	--	0	0	15	7

Table 2-11 Continued

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species	
		Acres	%	Units	Acres	%	Units	#(N_i)	(U_c)	Total	Units	# Per County	Units
Trimble	93,440	24,278	25	3	34,600	37	4	0	--	0	0	2	1
Union	217,600	100,450	46	5	37,594	17	2	0	--	0	0	6	3
Warren	349,440	135,442	39	4	90,600	26	3	2	1	2	0	11	7
Washington	196,480	35,267	18	2	47,100	24	3	0	--	0	0	3	1
Wayne	281,600	31,342	11	2	178,941	64	7	0	--	0	0	7	5
Webster	216,960	95,073	44	5	67,800	31	4	0	--	0	0	4	3
Whitley	293,760	45,141	15	2	196,566	67	7	2	1	2	0	5	3
Wolfe	145,280	7,637	5	1	92,622	64	7	2	1	2	0	5	3
Woodford	123,520	47,509	46	5	8,700	7	1	3	1	3	1	1	1

[1] U_c = uniqueness coefficient where:
1 = normal
2 = medium
3 = high

N_i = number of natural areas in each uniqueness category

Sources: (Babcock 1977; Kentucky Conservation Needs Inventory Committee 1970; Stine 1977; The Nature Conservancy 1976.)

TABLE 2-12. OHIO TERRESTRIAL ECOSYSTEM BASELINE DATA

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species	
		Acres	%	Units	Acres	%	Units	#(N_i)	(U_c)	Total	Units	# Per County	Units
Adams	376,320	81,377	22	3	187,100	50	5	1 5 7	3 2 1	20	7	7	5
Allen	262,400	209,668	80	8	23,010	9	1	3	1	3	1	0	0
Ashland	267,520	138,303	52	6	51,388	19	2	1 2 5	3 2 1	12	4	1	1
Athens	322,290	34,445	11	2	180,043	56	6	2 2	2 1	6	2	7	5
Auglaize	256,000	215,318	84	9	20,840	8	1	4	1	4	1	0	0
Belmont	342,273	25,093	7	1	124,492	36	4	2 3	2 1	7	2	3	1
Brown	314,019	86,182	27	3	76,800	24	3	1 3	2 1	5	1	2	1
Butler	301,240	151,501	50	5	31,793	11	2	1 7	3 1	10	3	2	1
Carroll	248,320	57,449	23	3	113,800	46	5	1 2	2 1	4	1	4	3
Champaign	277,064	205,174	74	8	32,804	12	2	1 4 5	3 2 1	16	6	3	1
Clark	257,177	156,071	61	7	23,875	9	1	4	1	4	1	3	1
Clermont	292,920	80,079	27	3	91,000	31	4	7	1	7	2	3	1
Clinton	263,040	174,335	66	7	17,113	7	1	7	1	7	2	1	1
Columbiana	342,103	78,539	23	3	88,768	26	3	3 8	2 1	14	5	7	5
Coshocton	348,800	48,130	14	2	148,400	43	5	3	1	3	1	1	1
Crawford	258,485	199,812	77	8	25,080	10	1	1 2	2 1	4	1	1	1
Darke	387,150	320,347	83	9	24,515	6	1	1 5	2 1	7	2	1	1
Delaware	281,600	220,726	78	8	26,739	9	1	2 5	2 1	9	3	1	1
Fairfield	323,200	182,014	56	6	52,138	16	2	2 4	2 1	8	3	1	1
Fayette	259,840	227,873	88	9	11,867	5	1	1	1	1	0	1	1
Franklin	343,680	195,419	57	6	19,671	6	1	5 7	2 1	17	6	4	3
Gallia	300,991	47,955	16	2	154,600	51	6	3	1	3	1	4	3
Greene	266,060	192,868	72	8	19,000	7	1	1 1 5	3 2 1	10	3	1	1
Guernsey	332,160	47,639	14	2	155,400	47	5	1	1	1	0	1	1
Hamilton	264,960	29,649	11	2	33,409	13	2	8 11	2 1	27	10	2	1
Hardin	298,880	213,626	71	8	20,324	7	1	0	--	0	0	1	1
Harrison	257,920	27,034	10	1	138,700	54	6	3	1	3	1	3	1
Highland	352,640	138,833	30	4	84,200	24	3	1 6	2 1	8	3	2	1

Table 2-12 Continued

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species	
		Acres	%	Units	Acres	%	Units	#(Ni)	(Uc)	Total	Units	# Per County	Units
Hocking	268,650	30,248	11	2	173,084	64	7	1 2 12	3 2 1	19	7	2	1
Holmes	270,520	64,810	24	3	93,500	35	4	1 5	2 1	7	2	2	1
Jackson	268,256	24,271	9	1	141,200	53	6	1 11	2 1	13	5	3	1
Jefferson	268,040	14,246	5	1	148,200	56	6	2 1	2 1	5	1	4	3
Knox	334,720	140,036	42	5	68,507	20	2	1 3	2 1	5	1	1	1
Lawrence	291,840	23,546	8	1	169,200	58	6	3	1	3	1	3	1
Licking	439,040	204,082	46	5	86,262	20	2	1 2 5	3 2 1	12	4	1	1
Logan	295,040	188,475	64	7	30,495	10	1	1 8	2 1	10	3	1	1
Madison	296,660	272,070	92	10	13,275	4	1	1	1	1	0	1	1
Mahoning	268,160	71,772	27	3	31,026	12	2	1 5	2 1	7	2	5	3
Marion	259,200	201,084	78	8	23,861	9	1	0	--	0	0	2	1
Medina	271,200	69,028	25	3	41,814	15	2	4	1	4	1	1	1
Meigs	277,610	34,399	12	2	168,100	61	7	1	1	1	0	5	3
Mercer	290,560	258,633	89	9	23,438	8	1	1	1	1	0	0	0
Miami	260,480	200,207	77	8	18,901	7	1	1 9	2 1	11	4	3	1
Monroe	291,200	23,736	8	1	147,606	51	6	2 1	2 1	5	1	3	1
Montgomery	297,600	151,518	51	6	18,250	6	1	5	1	5	1	3	1
Morgan	266,880	24,579	9	1	115,000	43	5	1	1	1	0	2	1
Morrow	258,560	188,716	73	8	46,235	18	2	0	--	0	0	1	1
Muskingum	424,320	59,688	14	2	175,600	41	5	0	--	0	0	1	1
Noble	255,140	19,386	8	1	115,700	45	5	1 1	2 1	3	1	2	1
Perry	261,760	45,561	17	2	116,500	45	6	2	1	2	0	1	1
Pickaway	324,375	276,757	85	9	12,566	4	1	2 4	2 1	8	3	2	1
Pike	283,520	54,048	19	2	151,698	54	6	3	1	3	1	2	1
Portage	319,320	93,953	29	3	89,327	28	3	3 14	2 1	20	7	1	1
Preble	273,280	201,586	74	8	25,538	9	1	1 3	2 1	5	1	1	1
Richland	318,080	171,521	54	6	70,759	22	3	1 5	2 1	7	2	1	1
Ross	439,680	186,573	42	5	170,300	44	5	1 2	2 1	4	1	2	1
Scioto	389,760	55,966	14	2	254,500	65	7	3 1	2 1	7	2	4	3
Shelby	261,760	222,012	85	9	23,550	9	1	3	1	3	1	1	1

Table 2-12 Continued

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species	
		Acres	%	Units	Acres	%	Units	#(N_i)	(U_c)	Total	Units	# Per County	Units
Stark	366,720	124,434	34	4	67,120	18	2	2 8	2 1	12	4	3	1
Summit	264,229	61,905	23	3	46,411	18	2	2 13	2 1	17	6	1	1
Trumbull	291,145	87,271	22	3	86,224	22	3	3	1	3	1	1	1
Tuscarawas	352,640	80,019	23	3	156,300	44	5	1 7	2 1	9	3	1	1
Union	277,760	221,621	80	8	18,638	7	1	1	1	1	0	1	1
Vinton	263,040	23,413	9	1	193,900	74	8	1	1	1	0	1	1
Warren	261,120	134,601	52	6	33,042	13	2	2 2	2 1	6	2	1	1
Washington	407,680	32,296	9	1	239,500	59	6	1 6	2 1	8	3	5	3
Wayne	352,640	209,550	59	6	52,870	15	2	2 6	2 1	10	3	1	1
Wyandot	259,017	183,939	71	8	24,957	10	1	2	1	2	0	0	0

[1] U_c = uniqueness coefficient where: 1 = normal
2 = medium
3 = high

N_i = number of natural areas in each uniqueness category

Sources: (Anderson et al. 1976; Herrick 1974; Ohio Department of Natural Resources 1976; Ohio Department of Natural Resources 1978; Ohio Soil and Water Conservation Needs Committee 1971.)

TABLE 2-13. PENNSYLVANIA TERRESTRIAL ECOSYSTEM BASELINE DATA

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species	
		Acres	%	Units	Acres	%	Units	#(Ni)	(Uc)	Total	Units	# Per County	Units
Allegheny	467,200	51,191	11	2	86,278	18	1	1 15	2 1	17	6	2	1
Armstrong	419,840	95,199	23	3	218,900	52	6	1 3	2 1	5	1	0	0
Beaver	282,240	83,857	30	3	134,600	48	5	1 3	2 1	5	1	0	0
Butler	508,106	203,438	40	4	261,600	26	3	3 19	2 1	25	9	2	1
Cambria	444,800	99,005	22	3	284,600	64	7	4	1	4	1	2	1
Clarion	383,360	74,166	19	2	272,600	71	8	1	1	1	0	1	1
Clearfield	732,160	161,879	22	3	607,980	83	9	4	1	4	1	1	1
Elk	516,480	82,841	16	2	360,364	70	7	7	1	7	2	3	1
Fayette	508,160	106,252	21	3	317,300	62	7	2 12	2 1	16	6	2	1
Forest	266,240	34,716	13	2	138,066	52	6	3	1	3	1	4	3
Greene	369,280	36,743	10	1	147,752	40	4	2	1	2	0	0	0
Indiana	528,000	144,259	27	3	289,400	55	6	4	1	4	1	1	1
Jefferson	417,280	90,646	22	3	292,813	70	7	2	1	2	0	1	1
Lawrence	234,880	74,183	32	4	92,700	39	4	2 11	2 1	15	5	1	1
Mercer	435,840	19,895	5	1	147,625	34	4	1 15	2 1	17	6	1	1
Somerset	693,760	147,184	21	3	443,400	64	3	9	1	9	3	2	1
Venango	432,000	65,173	15	2	352,700	82	9	3	1	3	1	2	1
Washington	548,480	40,009	7	1	192,703	35	4	2	1	2	0	0	0
Westmoreland	654,710	169,710	26	3	312,100	48	5	5 15	2 1	25	9	3	1

[1] U_c = uniqueness coefficient where: 1 = normal
2 = medium
3 = high

N_i = number of natural areas in each uniqueness category

Sources: (Kay et al. 1979; Pennsylvania Soil Conservation Service 1970.)

TABLE 2-14. WEST VIRGINIA TERRESTRIAL ECOSYSTEM BASELINE DATA

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species[2]	
		Acres	%	Units	Acres	%	Units	#(N_i)	(U_c)	Total	Units	# Per County	Units
Barbour	215,040	10,010	5	1	130,327	61	7	0	--	0	0		
Boone	320,600	10,838	3	1	290,000	90	9	0	--	0	0		
Braxton	330,900	18,814	6	1	213,633	65	7	2	1	2	0		
Brooke	57,000	3,937	7	1	23,900	42	5	1	1	1	0		
Cabell	178,560	22,377	13	2	118,203	66	7	1	1	1	0		
Calhoun	179,800	9,118	5	1	138,600	77	8	0	--	0	0		
Clay	218,900	5,022	2	1	189,350	87	9	2	1	2	0		
Doddridge	204,200	17,393	9	1	149,625	73	8	0	--	0	0		
Fayette	421,760	22,523	5	1	352,400	84	9	4	1	4	1		
Gilmer	217,000	11,747	5	1	167,468	77	8	0	--	0	0		
Grant	304,190	16,319	5	1	219,014	72	8	3	1	3	1		
Greenbrier	656,480	31,693	5	1	401,860	61	7	5	1	5	1		
Hancock	52,500	8,228	16	2	24,600	47	5	1	1	1	0		
Harrison	267,520	13,881	5	1	115,079	43	5	1	1	1	0		
Jackson	296,320	23,960	8	1	206,179	70	7	2	1	2	0		
Kanawha	581,100	14,738	3	1	453,500	78	8	3	1	3	1		
Lewis	250,900	10,688	4	1	134,300	54	6	1	1	1	0		
Lincoln	280,320	13,125	5	1	245,545	88	9	1	1	1	0		
Logan	291,800	3,869	1	1	260,500	89	9	0	--	0	0		
McDowell	341,120	3,073	1	1	302,500	89	9	1	1	1	0		
Marion	197,800	9,284	5	1	120,000	61	7	1	1	1	0		
Marshall	195,800	9,455	5	1	110,920	57	6	0	--	0	0		
Mason	276,400	37,102	13	2	162,304	59	6	0	--	0	0		
Mercer	266,900	17,799	7	1	186,445	70	7	3	1	3	1		
Mingo	270,720	3,852	1	1	242,300	90	9	0	--	0	0		
Monongalia	233,500	10,353	4	1	144,940	62	7	4	1	4	1		
Monroe	302,600	16,874	6	1	185,035	61	7	1	1	1	0		
Nicholas	412,600	19,991	5	1	312,923	76	8	3	1	3	1		
Ohio	68,500	5,267	8	1	21,407	31	4	1	1	1	0		
Pleasants	83,200	3,916	5	1	68,910	83	9	1	1	1	0		
Pocahontas	603,520	28,338	5	1	209,431	35	4	11	1	11	4		
Preston	412,800	64,071	16	2	273,700	66	7	6	1	6	2		
Putnam	223,400	22,586	10	1	166,986	75	8	1	1	1	0		
Raleigh	386,230	19,121	5	1	295,115	76	8	3	1	3	1		
Randolph	663,100	31,064	5	1	383,218	58	6	11	1	11	4		
Ritchie	289,280	23,657	4	1	197,200	30	3	4	1	4	1		
Roane	311,000	17,946	6	1	197,800	64	7	2	1	2	0		
Summers	228,900	17,486	8	1	152,321	67	7	2	1	2	0		

Table 2-14 Continued

County	Area (Acres)	Class I & II Soils			Forest			Natural Areas[1]				Endangered Species[2]	
		Acres	%	Units	Acres	%	Units	#(N_i)	(U_c)	Total	Units	# Per County	Units
Taylor	108,800	4,854	4	1	55,900	51	6	1	1	1	0		
Tucker	269,400	14,179	5	1	139,600	52	6	4	1	4	1		
Tyler	163,800	14,184	9	1	105,716	65	7	3	1	3	1		
Upshur	225,300	12,486	6	1	131,400	58	6	1	1	1	0		
Wayne	328,320	19,568	6	1	270,300	82	9	0	--	0	0		
Webster	352,600	4,962	1	1	266,099	75	8	4	1	4	1		
Wetzel	231,700	8,883	4	1	196,067	85	9	0	--	0	0		
Wirt	149,800	12,514	8	1	109,932	73	8	1	1	1	0		
Wood	235,500	27,028	11	2	145,900	62	7	2	1	2	0		
Wyoming	322,600	8,454	3	1	287,637	89	9	1	1	1	0		

[1] U_c = uniqueness coefficient where: 1 = normal
2 = medium
3 = high

N_i = number of natural areas in each uniqueness category

[2] There were no available data for the sub-state distribution of vertebrates for West Virginia.

Sources: (Cardi 1979; West Virginia Soil Conservation Service 1970.)

TABLE 2-15. SUMMARY OF TERRESTRIAL ECOSYSTEM VARIABLES IN THE ORBES REGION (FROM COUNTY TOTALS)

State	ORBES Acres	%	Natural Areas (No.)	Class I and II Soils Acres	%	Forest Acres	%	Endangered Vertebrate Species (No.)
Illinois	32,797,350	27	426	18,289,215	56	3,275,470	10	227
Indiana	20,595,959	17	137	12,037,894	58	3,556,697	17	317
Ohio	20,620,254	17	370	8,517,044	41	5,659,823	27	308
Kentucky	25,555,881	21	67	5,875,984	23	10,988,246	43	92
Pennsylvania	8,842,880	7	150	1,780,346	20	4,953,481	56	17
West Virginia	13,428,780	11	99	756,627	6	9,276,089	69	*
ORBES REGION	121,841,104	100	1,249	47,257,110	39	37,709,806	31	961

*No sub-state endangered vertebrate species data were available for West Virginia.

TABLE 2-16. KEY TO INDICES USED FOR TERRESTRIAL ECOSYSTEM ASSESSMENT UNITS

Endangered Species		Natural Areas		Soil Productivity		Forest
Number Per County	Units	$\sum_{c=1}^{3} \frac{U_c N_i}{50}$*	Units	Class I & II Soils Percentage of County	Units	
0	0	0-5	0	0	0	Same as for Soils
1-3	1	6-10	1	1-10	1	
4-6	3	11-15	2	11-20	2	
7-10	5	16-20	3	21-30	3	
11-15	7	21-25	4	31-40	4	
16-20	9	26-30	5	41-50	5	
>20	10	31-35	6	51-60	6	
		36-40	7	61-70	7	
		41-45	8	71-80	8	
		46-50	9	81-90	9	
		>50	10	91-100	10	

*U_c = uniqueness coefficient where: 1 = normal
2 = medium
3 = high

N_i = number of natural areas in each uniqueness category

Class I and II soils, as defined in the inventories, represent the most productive soils. Soils in class I have few limitations that restrict their use. They are suited to a wide range of plants and may be used safely for cultivated crops, pasture, woodland, and wildlife. Soils in class II have some limitations that reduce the choice of plants or require moderate conservation practices. However, the limitations are few and the practices easy to apply. Class II soils may be used for cultivated crops, pasture, woodland, or for wildlife food and cover.

The number of acres of land having class I or II soils is given for each ORBES county in Tables 2-9 through 2-14. Figure 2-10 shows the distribution of these soils in the ORBES region. The acreages of class I and II soils included in the tables and figure are presently in a number of land uses, including: cropland, pasture and range, orchards, forests and other open lands. These lands have a high potential productivity for agriculture and silviculture.

Natural Areas--

Lindsey (1969) defines a natural area as "any outdoor site that contains an unusual biological, geological, or scenic feature or else illustrates common principles of ecology uncommonly well." In recognizing the ecological significance of natural areas, many states have developed extensive natural areas programs. As a part of these programs, natural areas are identified and often times ranked a-cording to uniqueness and preservation status.

The number and distribution of natural areas, by county, for the ORBES states is presented in Tables 2-9 through 2-14 and in Figure 2-11. Both uniqueness and number of natural areas for each ORBES county were used in calculating the units and used in preparing Figure 2-11. Table 2-16 shows how unit values were calculated for natural areas and other terrestrial ecosystem variables.

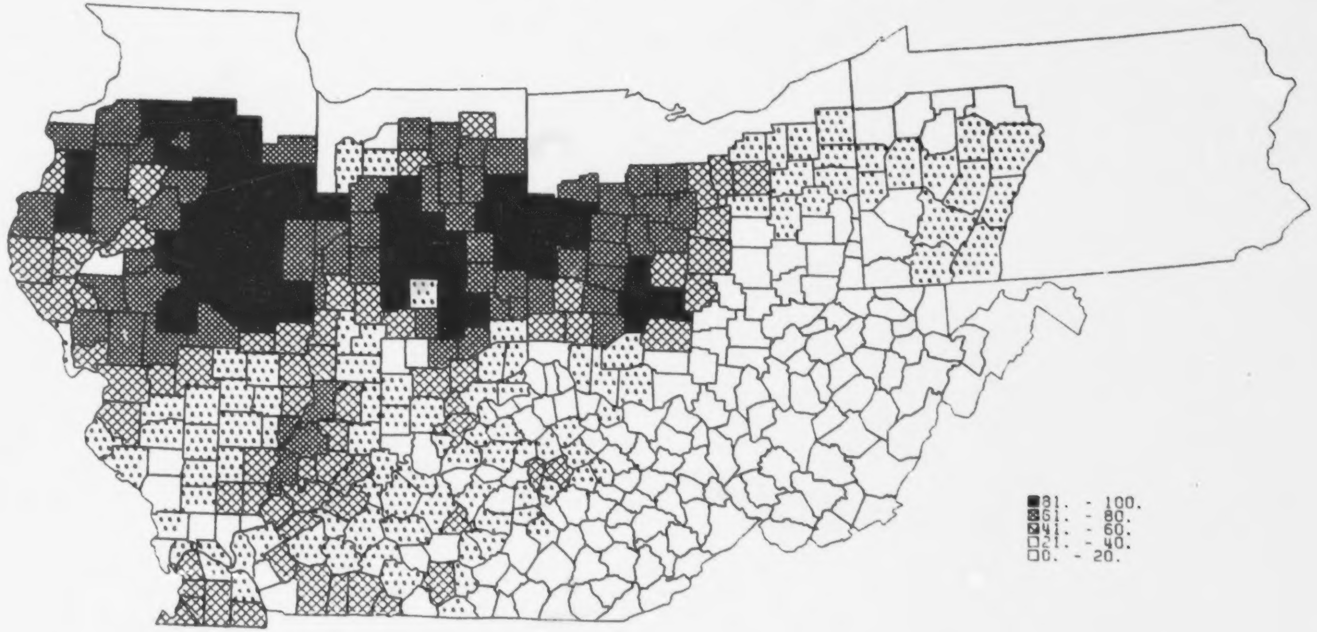
Because of variations in the emphasis placed on natural area programs among the ORBES states, care should be taken to only compare natural area distribution and abundance between counties of the same state rather than between states. For example, Illinois has recently completed a thorough natural areas survey whereas Kentucky's natural areas program is not as well-developed. These differences in policy are well illustrated in Figure 2-11.

The distribution and abundance of natural areas in the ORBES region are useful elements of the ecological baseline in that natural areas can serve as indicators of environmental significance. Natural areas can include relic communities representing pre-settlement conditions, critical habitat for rare or endangered species, unusual examples of flora and/or fauna, and other features of scientific or educational value. As indicators of environmental significance, natural areas can be useful in describing the environmental quality of the ORBES counties.

Unique and Endangered Species--

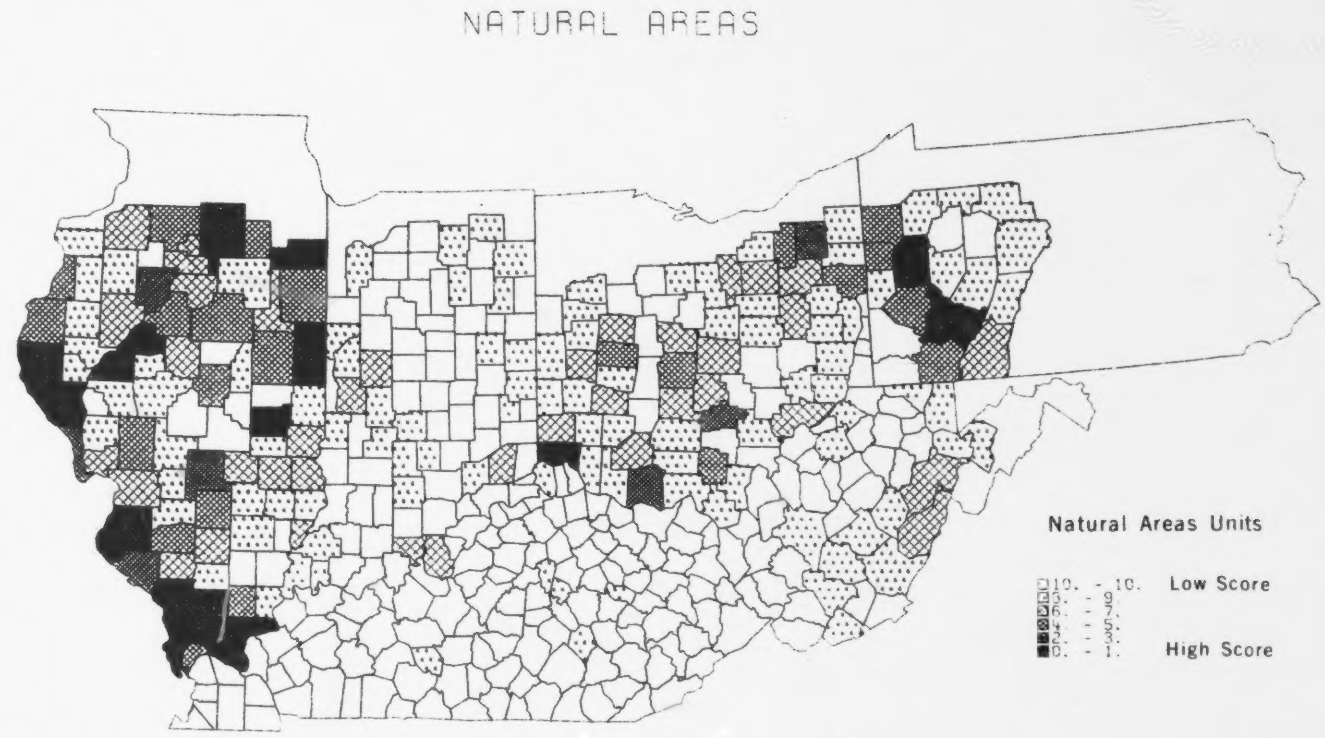
Several species in the ORBES region, though not endangered, may be regarded as unique elements of our biological heritage, because they represent surviving members of families with many extinct species. As they have few or no close relatives, several of these unique species, such as paddle-

SOIL PRODUCTIVITY: LAND CAPABILITY CLASSES I & II
PERCENTAGE OF COUNTY


▇81. - 100.
▩61. - 80.
▨41. - 60.
▢21. - 40.
▢0. - 20.

PREPARED FOR INDIANA UNIVERSITY SPEA
BY CAGIS UICC. SEPT 1979

FIGURE 2-10. SOIL PRODUCTIVITY IN THE ORBES REGION


NATURAL AREAS
Natural Areas Units
10. - 10. Low Score
8. - 9.
6. - 7.
4. - 5.
2. - 3.
0. - 1. High Score

PREPARED FOR INDIANA UNIVERSITY SPEA
BY CAGIS UICC SEPT 1979

FIGURE 2-11. NATURAL AREAS DISTRIBUTION

fish, hellbender, alligator snapping turtle, and beaver, are quite strange in appearance. Others, though not strange looking in themselves, are impressive when seen in their natural habitats; these include bald cypress, sycamore, cave blindfish, osprey, wild turkey, and cedar waxwing.

In general, riparian habitats support the greatest number of unique species; more specifically, the preferred habitat type is meandering river bordered by southern floodplain forest. In the ORBES region, this community occurs in Posey County, Indiana, and is represented in discontinuous blocks downstream along the Wabash and Ohio Rivers and along the Mississippi River adjacent to and downstream from southern Illinois. Most of those unique species intolerant of the southern floodplain habitat would be best accommodated within the ORBES region by mountains bordering large clear streams in eastern Kentucky.

In recognizing the "esthetic, ecological, educational, historical, recreational, and scientific value" of endangered and threatened species of fish, wildlife, and plants to the nation and its people; and recognizing its duty to conserve to the extent practicable the various species facing extinction; the U. S. Congress passed the Endangered Species Act of 1973 (Public Law 93-205). The law encourages the states and all federal agencies to conserve endangered and threatened species and to utilize their authorities in furtherance of the law.

In compliance with the law, federal and state agencies have identified those species that are endangered or threatened with extinction. During the three-year period (August 1976 through August 1979) in which the Endangered Species Technical Bulletin has been keeping its "Box Score of Species Listings," the number of domestic endangered and threatened species has risen from 178 to 239. The number of critical habitats has risen from 1 to 34. Inasmuch as mankind seems responsible for an abnormally high rate of extinction in contrast to the normal evolutionary process, future human acts, for example, large construction projects, that result in the conversion of wildlife habitat and could conceivably affect endangered species or critical habitats, must be closely scrutinized.

Animal species occurring in Indiana or Ohio and regarded by either of the two state governments or by the federal government as endangered are listed in the Phase I report (Indiana University et al. 1977). A list of plant species similar to that for animals but restricted to those regarded by the federal government as threatened or endangered is presented in the same report. Endangered plant and animal species in West Virginia and Pennsylvania are given in baseline reports for those states (Cardi 1979; Kay et al. 1979). Endangered animal species in Illinois are listed in the Phase I report (University of Illinois 1977) and in Ackerman (1975). The Phase I report for Kentucky did not discuss endangered species. A report by Babcock (1977) presents a thorough listing of endangered plants and animals of Kentucky.

The only terrestrial animal species that is listed by the federal government as endangered and is essentially restricted to the ORBES region is the Indiana bat (Myotis sodalis). In addition, a majority of the surviving population of Kirtland's warblers (Dendroica kirtlandii) probably migrate across Ohio seasonally. The federally endangered American peregrine falcon (Falco *peregrinus anatum*) is occasionally sited in the ORBES region during its migration.

The distribution and occurrence of endangered species at the substate level for the ORBES states is not widely known primarily due to the infrequent nature of sitings. Indiana bat wintering cave locations are an exception. For most species, however, only maps indicating suspected or previous ranges are available at the county level. The number of state and/or federally endangered or threatened vertebrate species having suspected ranges which include ORBES counties is given in Tables 2-9 through 2-14. Figure 2-12 gives a distribution map for these species. There were no available data for the substate distribution of vertebrates for West Virginia.

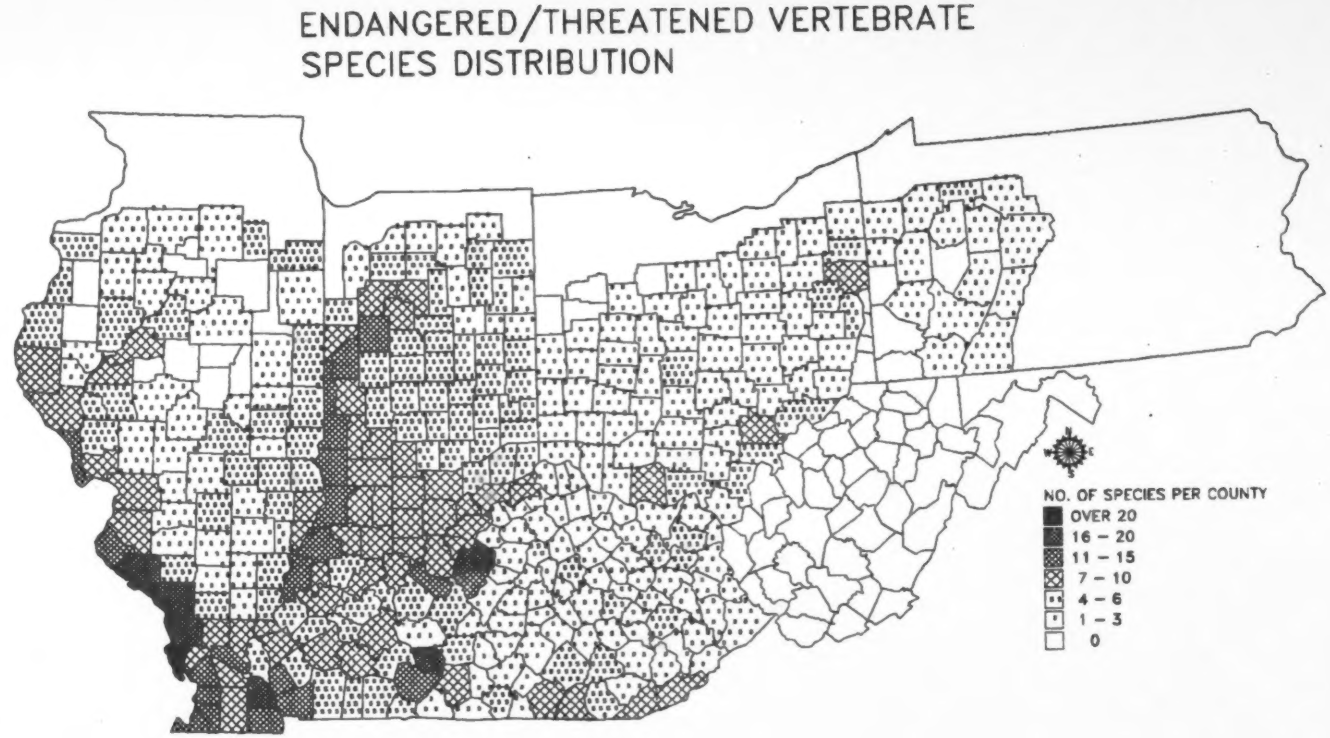
The occurrence of endangered species can be most thoroughly evaluated in impact assessments at the site-specific level. To be effective, an evaluation at this level must include (1) biological knowledge about each given species, (2) a thorough survey of all suspected habitats that could be affected by the proposed project, and (3) an understanding of the social and political tradeoffs involved in the decision making process.

Rare and endangered species can have important functions within terrestrial ecosystems. While the few common or "dominant" species usually account for much of the energy flow within a community, it is the large number of rare species that largely determines species diversity (Odum 1971). Although there are many theories concerning the role that species diversity plays in community stability, succession, and productivity, it remains generally accepted that high community stability is associated with a high level of species diversity, with no clear indication of which is dependent on the other. Although Odum refers to rare species in a broader sense than do state and federal legislation, rare and endangered species, as defined by state and federal law, represent a past and potential species diversity that is presently being lost.

Ecosystem Dynamics

The animals and plants described in the preceding sections interact with each other and with their physical environment in a complex, dynamic fashion. Although a detailed discussion of ecosystem dynamics is beyond the scope of thie report, this section contains brief descriptions of some of the ecological interactions occurring within each of the three most common rural biotic communities of the ORBES region--upland hardwood forests, farmlands, and riparian communities.

Upland Hardwood Forests--One of the most important community interactions is that of energy flow through food webs. Food sources vary from animal to animal and from time to time. Of the upland hardwood forest fauna, only insects feed on the mature leaves of hardwood trees. Most herbivorous vertebrates find the leaves too high in fiber relative to the nutrient content and tend to eat buds and flowers in the spring and early summer and berries, nuts, seeds, and tubers in the late summer, fall, and winter. Nuts in particular are present in rich supply in the oak-hickory forest, helping to support abundant populations of squirrels and, in the past, turkey. Green bark is an alternative winter food source for some species, such as mice, rabbits, and deer.


ENDANGERED/THREATENED VERTEBRATE SPECIES DISTRIBUTION
NO. OF SPECIES PER COUNTY
OVER 20
16 – 20
11 – 15
7 – 10
4 – 6
1 – 3
0

PREPARED FOR OHIO RIVER BASIN ENERGY STUDY
BY CAGIS/UICC, FEBRUARY, 1980

FIGURE 2-12. ENDANGERED/THREATENED VERTEBRATE SPECIES DISTRIBUTION

Occupying other niches in the forest food web are the birds, most of which, including the woodpeckers and songbirds, are insectivorous; the salamanders, which form a common and diverse group of forest floor predators; and the reptiles, which range in food habits from the carnivorous snakes to the omnivorous box turtle. The large forest predators of past and present include bobcat, gray fox, and owls.

One large portion of the forest fauna, migratory songbirds, is not resident throughout the year. These birds transport a fraction of the forest nutrients southward in the fall in their bodies. Inasmuch as many of them die in the winter and do not return, these birds constitute a small, seasonal drain on forest nutrient production. This loss is replenished by the gradual weathering of the soil.

Nutrient cycles in general play an important part in community dynamics. The annual growth cycle of the hardwood trees is the most pervading feature influencing the nutrient cycle of the upland hardwood forest and the growth cycles of other plants as well as animals. Most of the hardwoods flower before leafing out in the spring and bear fruit before or during leaf shed in the summer and fall, thus governing the food habits of herbivores as described above. Before leaf production by trees in the spring, the herbaceous plants of the forest floor are especially active, accounting for the commonly observed spring woodland wildflowers and the generally green aspect of the forest floor in middle and late spring. In warm, moist weather, fungi actively decompose leaves and twigs fallen from the previous fall. Many fungi gather energy in this fashion in the spring and early summer and bear fruit during wet periods in the later summer and fall. In the autumn, most of the leaves of a given tree tend to fall beneath it and in decomposing, release nutrients that are recovered by the parent tree. Generally, nutrient movement in the form of dissolved or particulate chemicals tends to be low in soil because dead leaf cover and decomposing humus retain the chemicals or, alternatively, give them up to the roots and above ground structures of living trees. The decomposing leaves may also inhibit growth in young members of the same species or in members of other species by a complex, little-understood process known as allelopathy.

The upland hardwood forest community tends not to be continuous and uniform over broad areas, because it experiences periodic variation due to wildfires, tornadoes, and local individual tree falls. These phenomena open up patches of the forest floor to direct sunlight in summer when adjacent areas are shaded.

Farmland Communities--Farmland communities vary from large areas of continuously cropped land interspersed with farmsteads (buildings and any yard trees, bushes, and flower gardens), through fields interrupted by woody hedgerows and small wood lots, to large wooded tracts interspersed with grazed brushland and small tilled areas. A major feature is the transitional "edge" community occurring where wooded and nonwooded land meet.

Lateral nutrient transport is an important feature in farmland communities. It occurs through soil erosion, harvest and removal of crops and application of fertilizer.

The annual floral growth cycle is partly natural and partly governed by agricultural practice. The natural fraction is a mixture of the hardwood forests and old-field successional cycles. Old-field plants generally flower in the late spring and summer and bear seeds during the summer and fall. In the wooded areas, the woodland spring flora is often reduced because the woods are too open and brushy for them or because the plants have been trampled by grazing animals or displaced by pastoral plants.

The animal portion of farmland communities is composed of livestock, wildlife, and agricultural insect pests. In intensively farmed areas, the vertebrate wildlife consists of highly mobile birds and mammals. If there are farm ponds, toads and, to a lesser extent, frogs may be present. Some birds, including pheasants, bobwhite quail, and sparrows, nest within cropped land (e.g., alfalfa), but most birds and mammals tend to roost, nest or den in the wooded and brushy areas and to feed in weeds along the edges of these areas or in the croplands. Species exhibiting this behavior include herbivores such as doves, rabbits, and woodchucks; omnivores such as crows, blackbirds of several species, opossum, and striped skunk; and the predatory red fox, hawks, kingbirds, and robins.

As land use departs from intensive agriculture and trends toward abandoned old fields and brushlands, particularly in association with forest areas, wildlife diversity may increase substantially, with the inclusion of snakes, voles, deer, and more songbirds. Some wildlife characteristic of permanent prairies may inhabit advanced old fields, but since these areas are in a state of change woodland eventually takes over. Functional features distinguishing the old field-brushland community from the hardwood forests include solar heating near the ground, denser ground cover due to brush and herbaceous vegetation, and the summer flowering and fruiting periods of the vegetation present. The solar heating and ground cover enhance diversity of reptiles, while the summer flowering and fruiting period permits a higher degree of herbivory in small birds than is encountered in hardwood forests.

Riparian Communities--The most obvious feature of riparian communities is the juxtaposition of land and moving water. A number of habitats may be available at the land-water interface due to temporal and geographical variations in the effects of streamflow upon the land. Such habitats include open and snag-covered high banks and sand banks associated with the main stream, oxbow ponds, marshes, and swamps of severed channels, as well as annual floodplains and alluvial terraces.

The lateral transport of dissolved and particulate nutrients in stream water can be moderate to great in quantity relative to the lateral nutrient transport which occurs in upland hardwood forests. Natural nutrient sources include soil erosion of untilled soils and the decomposition of dead leaves and other detritus washed into the water, while artificial sources are represented by erosion of tilled land, feedlot runoff, and urban wastes. The most important aspects of nutrient transport for the terrestrial portions of riparian communities is the deposition of silt-borne nutrients on floodplains during floods. It would appear that the rate of this deposition has increased over the past decades, as historical descriptions of the Ohio River Basin indicate that presently murky waters were once clear.

The annual cycle of nutrient movement through riparian communities and the resultant community productivities vary among habitats according to the degree of annual inundation by water. The high points of sand bars above flood levels are natural habitats for relatively xeric old field herbs and woody brush. These communities have typical old field seasonal cycles. In an average year, the terraces may not flood either, and the forests growing on them behave much like upland hardwood forests. The major differences include the greater soil fertility of the terraces and differences in forest species composition. Seasonally flooded areas support flood-tolerant vegetation, which during high water periods survives as emergent woody vegetation (trees such as sycamore, silver maple, willow, and water tupelo; shrubs such as buttonbush and swamp-privet), rootstocks, or seeds. Whereas the herbaceous flora of the upland woods generally produces flowers and succulent leaves in the spring, such growth may not occur until well into the summer in riparian communities that flood in the spring. Mud bars along oxbows may support succulent vegetation into late summer, providing food for muskrat, swamp rabbit, and other riparian herbivores. Vegetation of oxbow ponds grades from terrestrial into emergent and submerged aquatic species. The greatest production tends to occur during late spring and summer.

The vertebrate fauna of riparian communities is probably the most diverse within the ORBES region. The fauna of the alluvial terraces often includes species also found in upland hardwood communities, some as permanent residents and some as upland visitors that have come to the river for water. The annual floodplains support a uniquely riparian amphibian community and also moles that burrow through exposed soils. Oxbows are inhabited by uniquely riparian amphibians (including tree frogs) and reptilian communities. A distinct unique reptilian community may be found along the main channel.

The general riparian avifauna includes many species that feed on aquatic and emergent aquatic insects. Examples are wood duck, killdeers, swallows, and many species of warblers. Fish-eating birds include mergansers, herons, ospreys, bald eagles, and kingfishers. The total number of animal species that feed on aquatic life but reproduce on land is quite large, so that loss of aquatic life through degraded water quality may result in loss of these terrestrial animals.

Animals not associated with a particular riparian community include snakes and turtles; migratory ducks and geese, which rest on water and feed in grain fields; raccoon and striped skunk, which feed in uplands as well as lowlands; and bats, which winter in upland caves and feed over streams and possibly reproduce in riparian trees.

SECTION 3

SCENARIOS

3.1 SCENARIO METHODOLOGY

The Ohio River Basin Energy Study is a regional technology assessment utilizing a research design characterized as a "scenario" methodology. Because the purpose of the ORBES project is to inform decision makers and the general public of implications associated with energy development in the Ohio River valley through the year 2000, it was important that the study examined as many plausible future energy and environmental conditions (scenarios) as time and resources permitted. Scenarios are not forecasts of what "the future" will be, but rather represent alternative plausible futures which depend upon the course of events and selection of alternative, but likely, policies and conditions.

A number of scenario models were used in conjunction with present-day regional conditions to specify a plausible set of future energy and fuel use characteristics in the ORBES region. These models included: energy and fuel demand, economic growth, population projections, coal supply and allocation, and siting of additions to regional generating capacity.

3.2 SCENARIO DESCRIPTIONS

A brief description of the ORBES scenarios analyzed in this study is presented in Table 3-1. The scenarios are variations and combinations of assumed types of energy conversion technologies, environmental control standards, and levels of economic growth. All scenarios encompass the base period (the mid-1970's) through the year 2000. A description of the basic scenario assumptions for environmental controls and for economic growth are presented in Table 3-2.

TABLE 3-1. DESCRIPTION OF BASIC ORBES SCENARIOS

Scenario	Technology	Environmental Controls	Economic Growth
Fossil Fuel Emphasis			
1	conventional, coal emphasis	strict	high
1a	conventional, coal emphasis	strict (very strict air quality), dispersed siting	high
1b	conventional, coal emphasis	strict (very strict air quality), concentrated siting	high
1c	conventional, coal emphasis	strict (strict agricultural land protection), dispersed siting	high
1d	conventional, coal emphasis	strict (strict agricultural land protection), concentrated siting	high
2	conventional, coal emphasis	base case	high
2a	conventional, coal-fired exports	base case	high
4	conventional, natural gas emphasis	base case	high
5	conventional, coal emphasis	base case	low
5a	conventional, coal emphasis	base case	very high
6	conventional, coal emphasis	base case	high (very low energy growth - 1.9% through 1985; 0.7% annual decline 1985-2000)
7	conventional, coal emphasis	base case	high (high electrical energy growth - 4.0%)
Nuclear Fuel Emphasis			
2b	conventional, nuclear-fueled exports	base case	high
2c	conventional, nuclear emphasis	base case	high
Alternative Fuel Emphasis			
3*	alternative	base case	high

TABLE 3-2. BASIC SCENARIO ASSUMPTIONS FOR ENVIRONMENTAL CONTROLS AND ECONOMIC GROWTH

ENVIRONMENTAL CONTROLS

	Lax	Base Case	Strict	Very Strict
Air	Air quality standards set by SIPs are not complied with.	Current urban SIPs in urban areas and current rural SIPs in rural areas are applied.	Stringent pollution emission standards for urban areas set by 1978 state implementation plans (SIP) under the Clean Air Act are applied.	No coal-fired additions sited in counties with current violations of national ambient air quality standards (NAAQS) for SO_2 and particulates and/or with less than full PSD increment available for 24-hour and secondary standards.
Water		Current effluent standards apply.	95% reduction in effluent is achieved using extensive recirculation of water.	
Land		Federal standards prior to SMCRA are applied.	Interim and permanent performance standards under the Surface Mining Control and Act of 1977 (SMCRA) are applied but with strengthened site-specific applications.	Ag lands protection: no additions in counties having greater than 50% Class I and II soils.

ECONOMIC GROWTH

Rate	Regional Growth (%)	National Growth (%)
low	2.1	3.26
high	2.47	3.26
very high	3.1	3.26

SECTION 4

SITING[1]

4.1 SITING METHODOLOGY

An ORBES siting model was developed to provide a means of converting the scenario policies into a geographical pattern of impacts that could be assessed and evaluated. Consistent with scenario policies, the required number of "new" base-load coal-fired and nuclear-fueled steam electric generating units are added to the network of existing and planned facilities. Policy changes can be simulated by the model when they are functionally related to the siting issues, that is, to the geographical and temporal allocation of new generating capacity.

The ORBES siting model depends upon the scenarios for three basic pieces of information: (1) regional energy demand for electric utilities, (2) energy technology characterizations, and (3) siting issues. The specification of final-year regional energy demand is necessary to calculate the generating capacity additions that must be sited. The technological characteristics of the "standard" generating units that are to be sited and the specification of fuel mix (by region or state) are needed to determine the number of scenario unit additions to be sited and to define the siting issues and date requirements. Siting issues include those areas relevant to the location of future generating units of primary concern to the assessment and to the policies it addresses.

The final demand for energy from electric utilities in the ORBES region in the year 2000 was allocated to state subregions on the basis of the distribution of projected demand in 1985. The existing installed and planned capacity for which sites have been announced was then subtracted from the "required" capacity to determine the total unisted additions. These additions were translated into the number of standard coal-fired and nuclear-fueled units (scenario additions), as specified by the scenario, to be located according to the site suitability of ORBES-region counties.

The suitability of ORBES counties as sites for future electrical generating stations was determined by using a linear weighted suitability model. Siting issues were represented in the model by specific variables for which quantitative data were collected at the county level. These variables included: maximum 24 hour sulfur dioxide concentration, maximum 24 hour particulate concentration, public lands, natural areas, class I and II soils, forest lands, water availability, seismic risk, and population density. Weights for each variable were adjusted to reflect policy and technology assumptions within each of the scenarios.

Utility plans for capacity additions were used to meet short-term regional energy demand only. Scenario addition units were sited after 1985. The scenario unit additions, by fuel type, were allocated within each state subregion, two units at a time, according to the rank order suitability indices of the candidate counties. A county could be selected more than once provided that its total sited electrical generating capacity did not exceed 2,600 megawatts coal-fired and 4,000 megawatts nuclear-fueled. Scenario unit additions that could not be sited in the state subregion to which they were assigned were sited in an adjacent state.

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[1] Taken largely from Fowler et al. 1980.

4.2 SITING PATTERNS

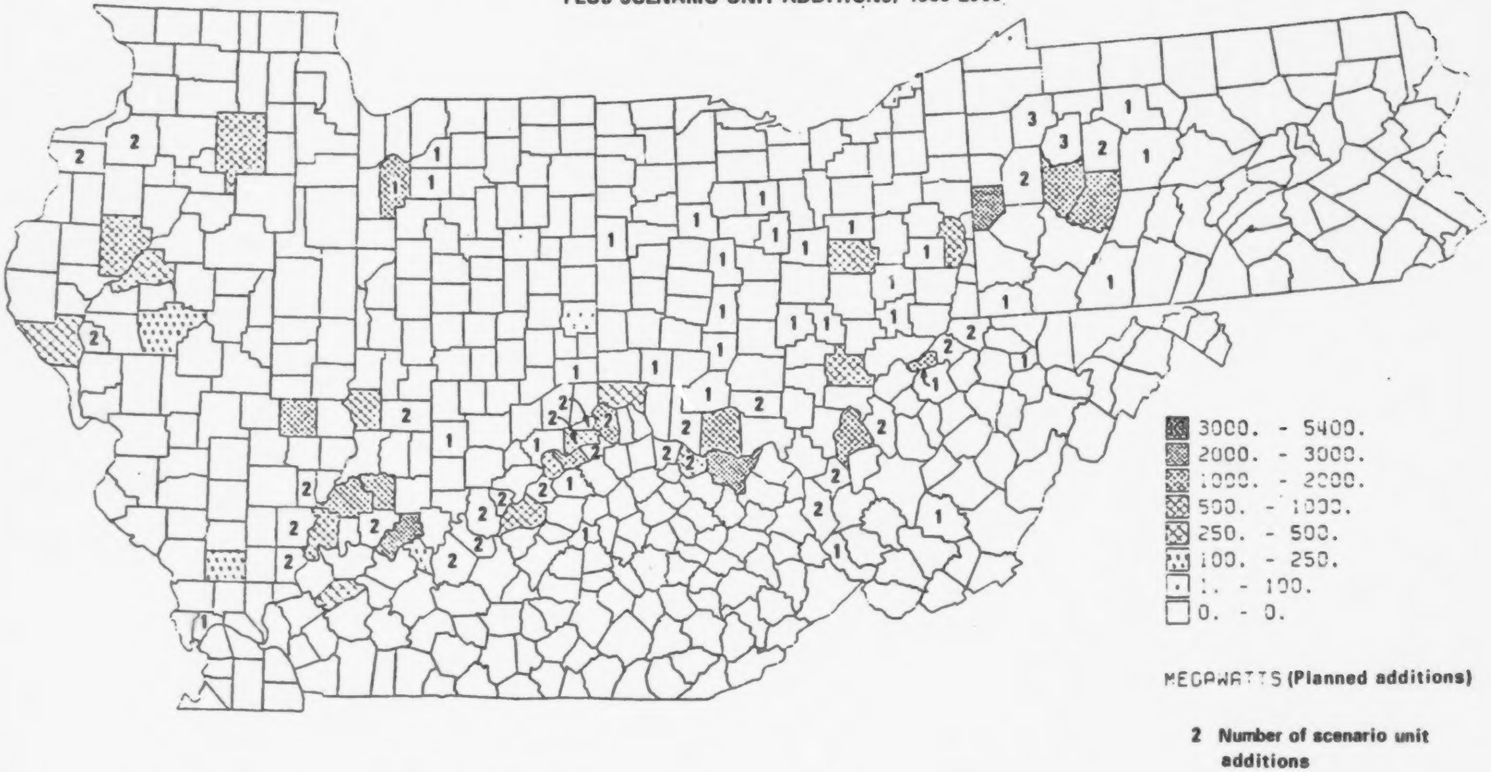
Figures 4-1 through 4-18 illustrate the regional siting patterns for scenario unit additions developed during the ORBES study for 15 scenarios. Capacity additions, as currently planned for by utilities, are also designated. Proposed nuclear capacity additions (Figure 4-2) are consistent for all scenarios. Tables 4-1 and 4-2 summarize the 15 siting patterns, giving the number of counties with facilities sited and the sited capacity for each state for planned, scenario, and total additions. The planned additions remain constant for all scenarios, however, the scheduling of these additions varied according to scenario.

Scenarios 2a, 5a, and 7 required the greatest total capacity additions; in excess of 116,000 megawatts each. Scenarios 2c, 4, and 6 required the fewest capacity additions, less than 60,000 megawatts each.

SCENARIO I: CONVENTIONAL TECHNOLOGY, STRICT CONTROLS

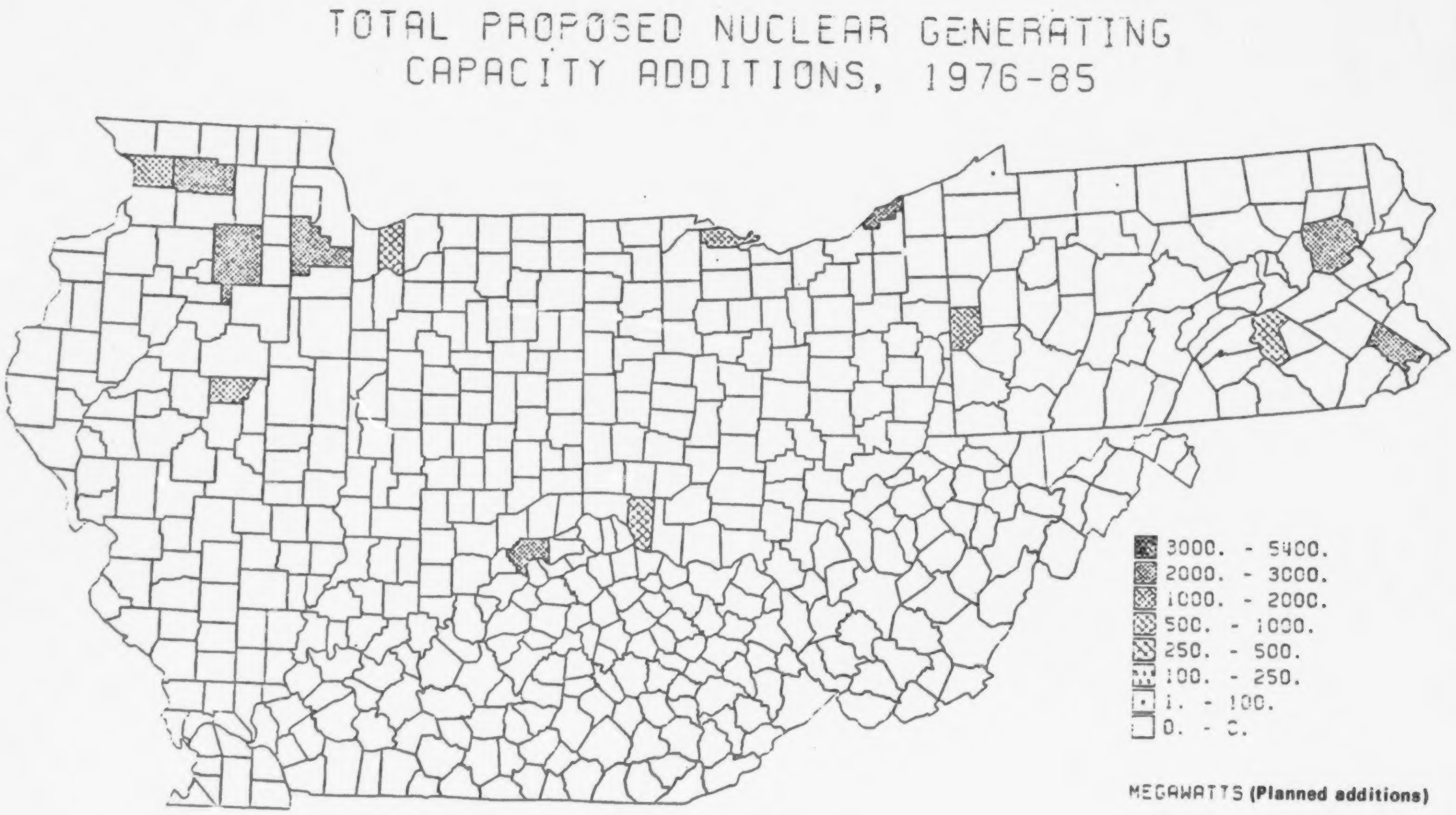
TOTAL PROPOSED COAL-FIRED GENERATING
CAPACITY ADDITIONS, 1976-85

PLUS SCENARIO UNIT ADDITIONS, 1986-2000


3000. - 5400.
2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Planned additions)
2 Number of scenario unit additions

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY CAGIS UICC AUGUST, 1979

FIGURE 4-1. COAL-FIRED CAPACITY ADDITIONS FOR SCENARIO 1



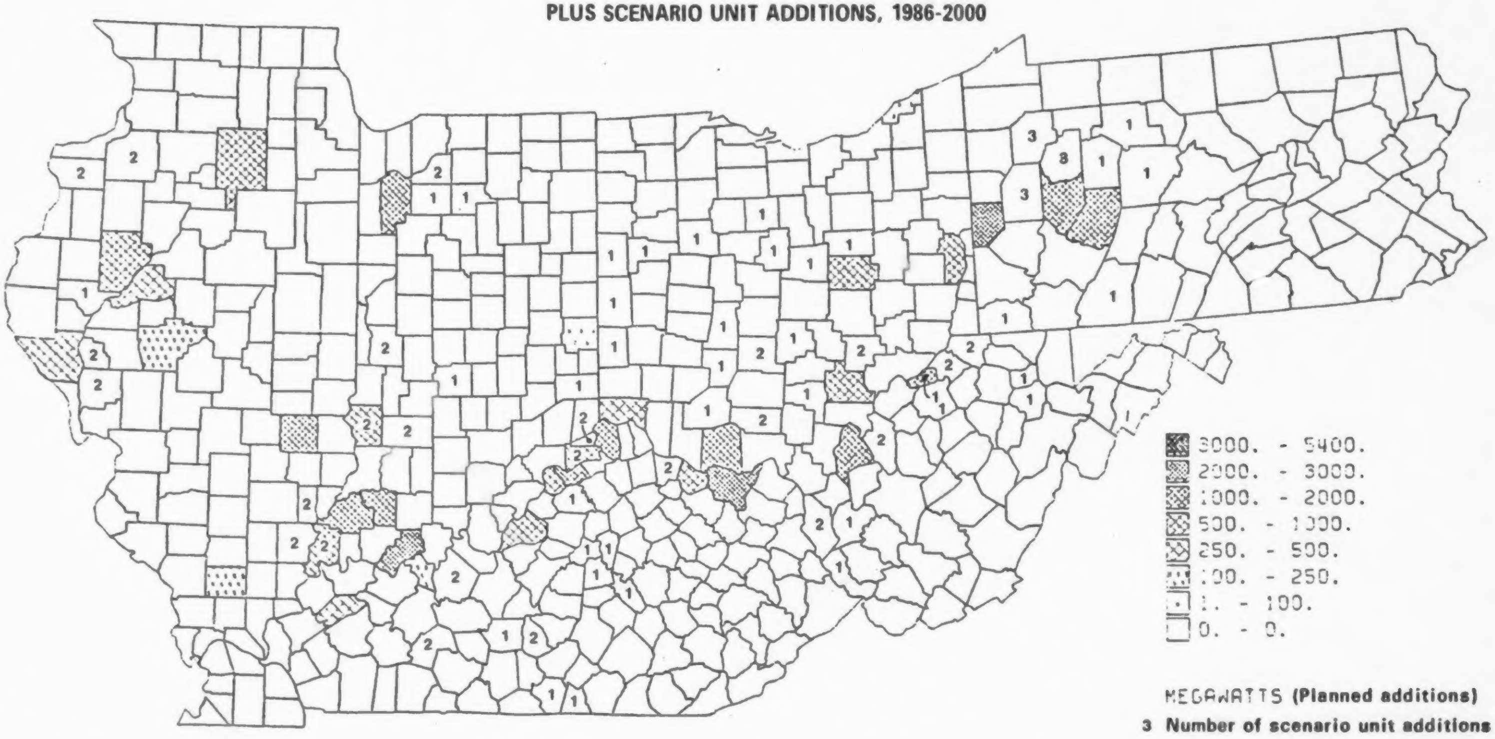
TOTAL PROPOSED NUCLEAR GENERATING CAPACITY ADDITIONS, 1976-85

3000. - 5400.
2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Planned additions)

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY [illegible] AUGUST, 1975

FIGURE 4-2. PROPOSED NUCLEAR-FUELED CAPACITY ADDITIONS FOR ALL SCENARIOS

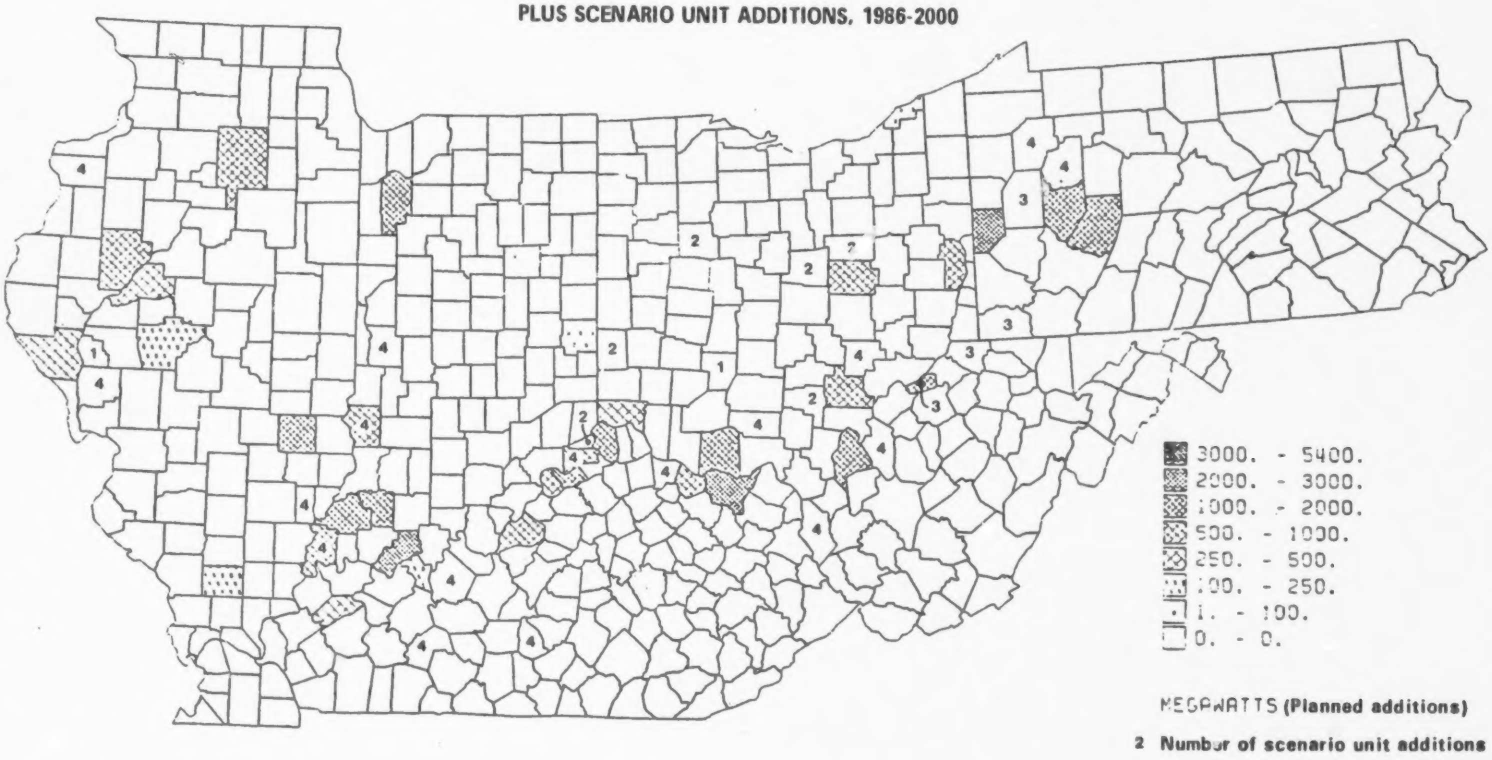
SCENARIO IA:
VERY STRICT AIR QUALITY CONTROLS, DISPERSED SITING
TOTAL PROPOSED COAL-FIRED GENERATING
CAPACITY ADDITIONS, 1976-85
PLUS SCENARIO UNIT ADDITIONS, 1986-2000


3000. - 5400.
2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Planned additions)
3 Number of scenario unit additions

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY CAGIS UICC AUGUST, 1975

FIGURE 4-3. COAL-FIRED CAPACITY ADDITIONS FOR SCENARIO 1a

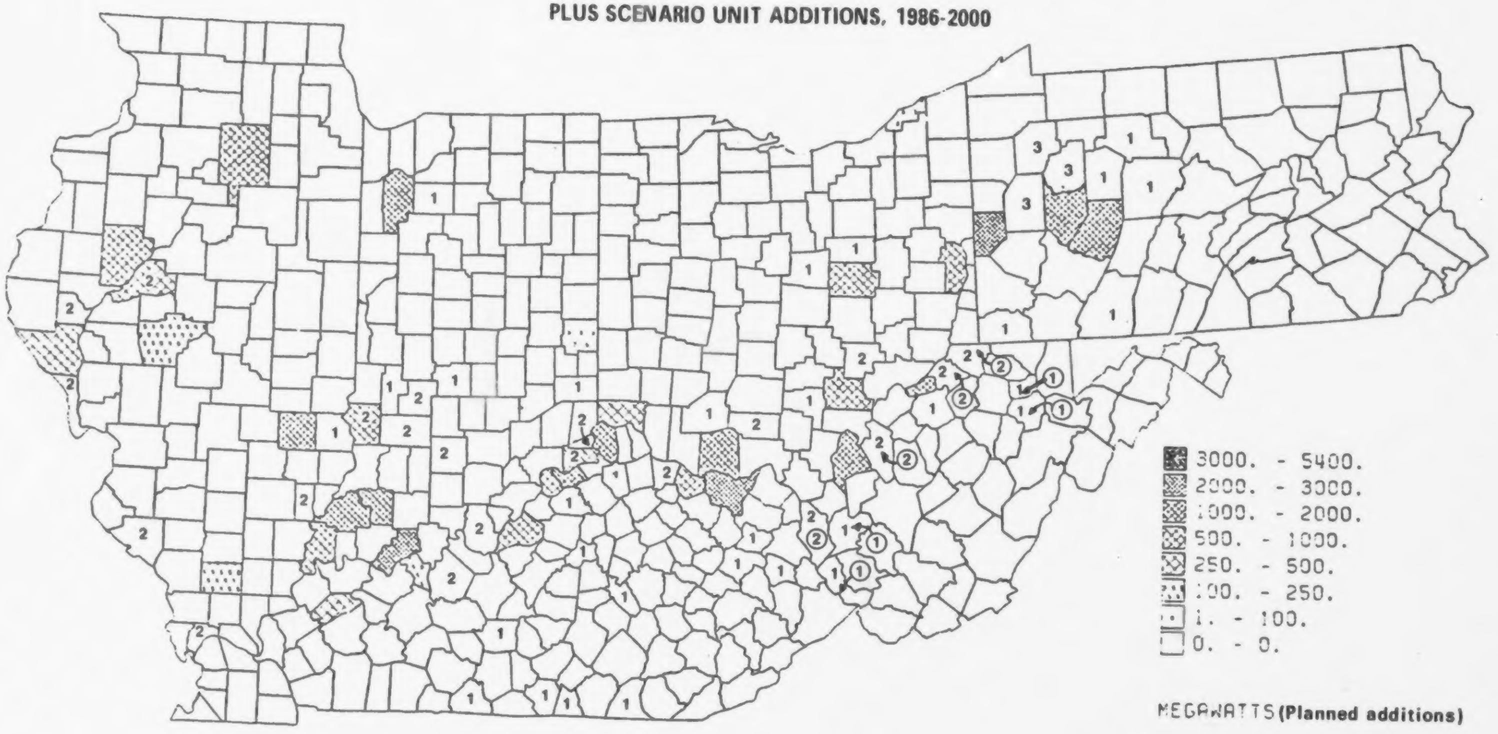
SCENARIO IB:
VERY STRICT AIR QUALITY CONTROLS, CONCENTRATED CITING
TOTAL PROPOSED COAL-FIRED GENERATING
CAPACITY ADDITIONS, 1976-85
PLUS SCENARIO UNIT ADDITIONS, 1986-2000


3000. - 5400.
2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Planned additions)
2 Number of scenario unit additions
4
1
2
3

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY CAGIS UICC AUGUST, 1975

FIGURE 4-4. COAL-FIRED CAPACITY ADDITIONS FOR SCENARIO 1b

SCENARIO IC:
AGRICULTURAL LANDS PROTECTION, DISPERSED SITING
TOTAL PROPOSED COAL-FIRED GENERATING
CAPACITY ADDITIONS, 1976-85
PLUS SCENARIO UNIT ADDITIONS, 1986-2000



▩ 3000. - 5400.
▩ 2000. - 3000.
▩ 1000. - 2000.
▩ 500. - 1000.
▨ 250. - 500.
▨ 100. - 250.
☐ 1. - 100.
☐ 0. - 0.

MEGAWATTS (Planned additions)

3 Number of scenario unit additions

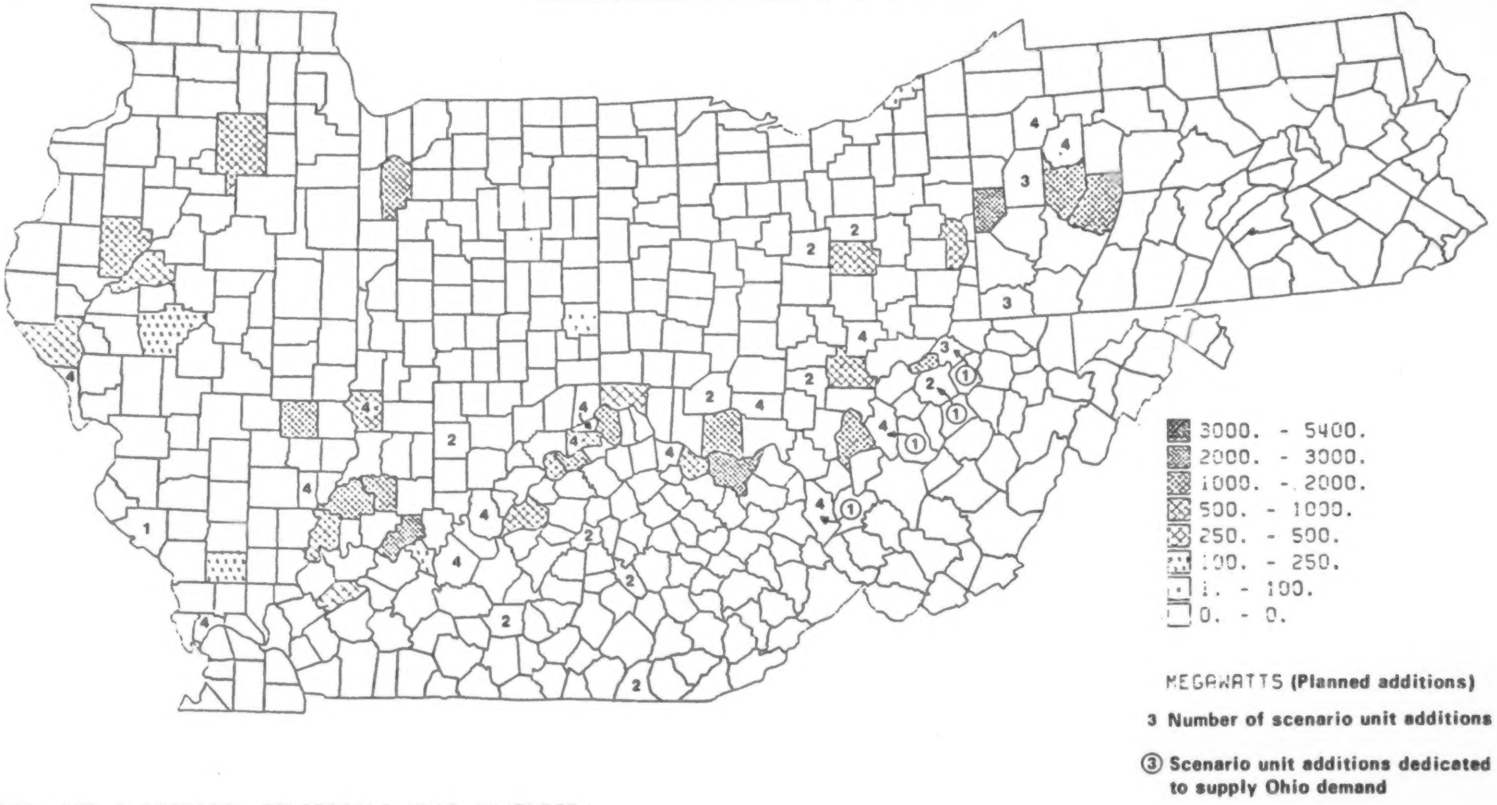
③ Scenario unit additions dedicated to supply Ohio demand

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY CASIS VICE AUGUST, 1979

FIGURE 4-5. COAL-FIRED CAPACITY ADDITIONS FOR SCENARIO 1c

SCENARIO 1D:
AGRICULTURAL LAND PROTECTION, CONCENTRATED SITING

TOTAL PROPOSED COAL-FIRED GENERATING
CAPACITY ADDITIONS, 1976-85
PLUS SCENARIO UNIT ADDITIONS, 1986-2000

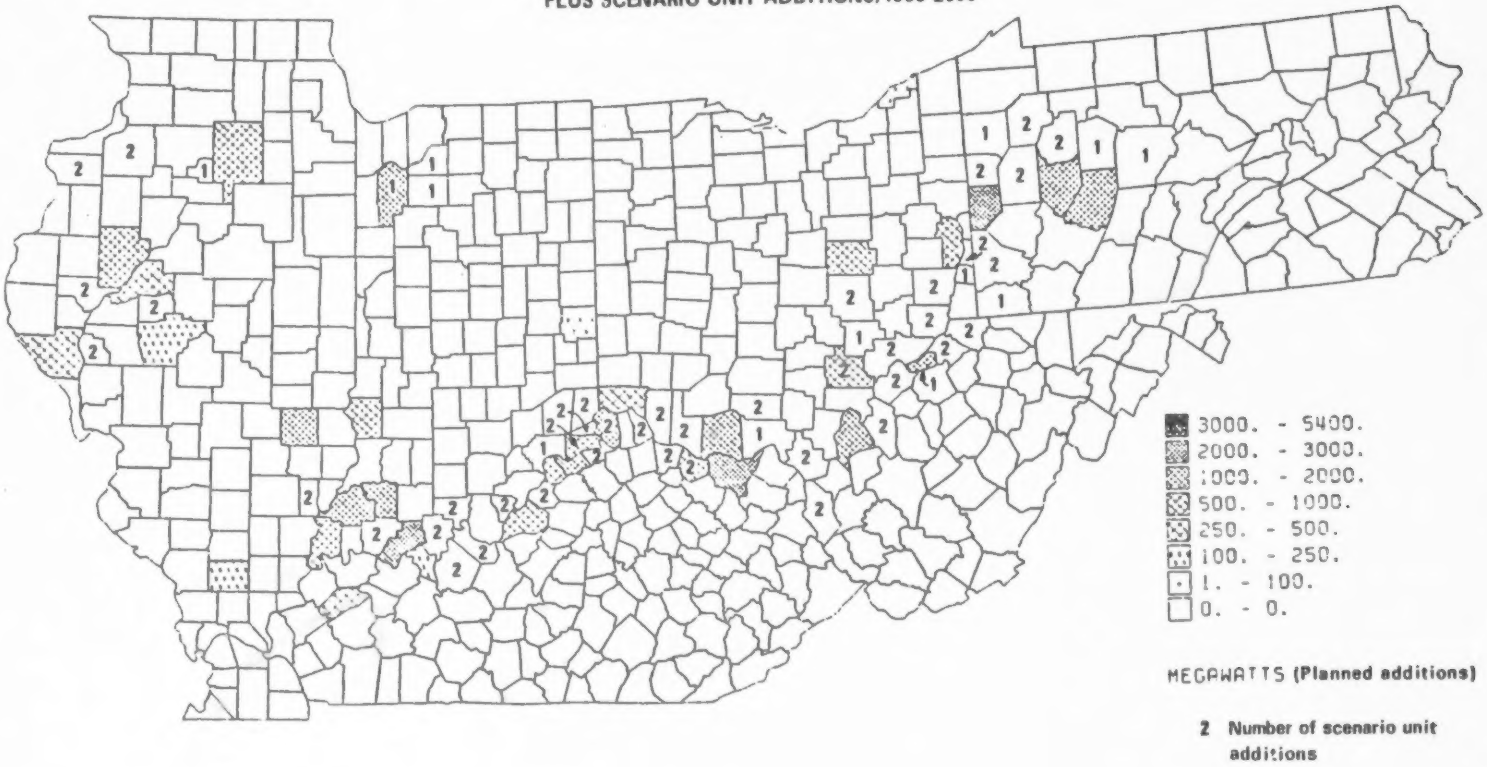


▩ 3000. - 5400.
▩ 2000. - 3000.
▩ 1000. - 2000.
▩ 500. - 1000.
▨ 250. - 500.
▨ 100. - 250.
☐ 1. - 100.
☐ 0. - 0.
MEGAWATTS (Planned additions)
3 Number of scenario unit additions
③ Scenario unit additions dedicated to supply Ohio demand
1
2
3
4
①

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY CAGIS UICC AUGUST, 1975

FIGURE 4-6. COAL-FIRED CAPACITY ADDITIONS FOR SCENARIO 1d

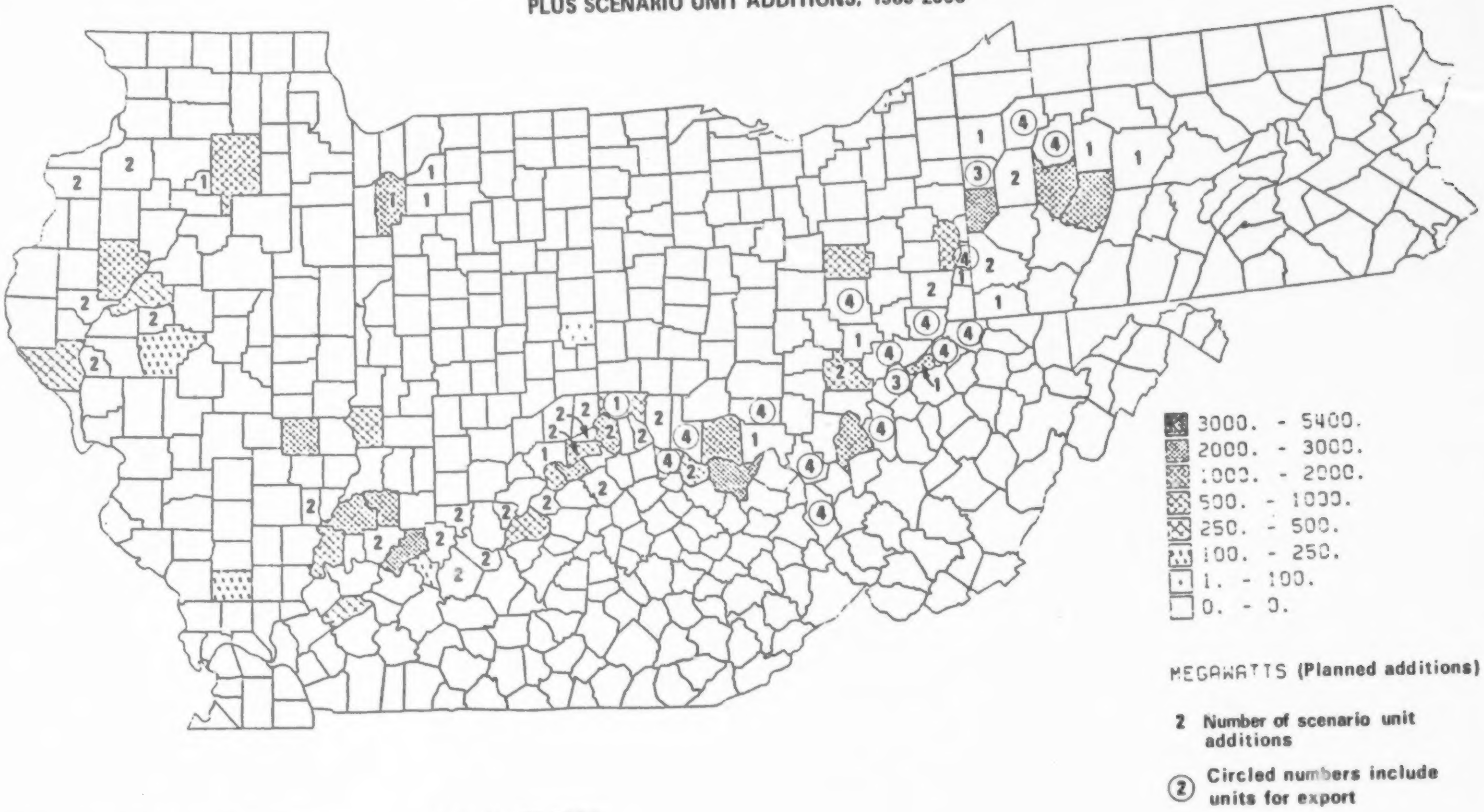
SCENARIO 2: CONVENTIONAL TECHNOLOGY, BASE CASE CONTROLS
TOTAL PROPOSED COAL-FIRED GENERATING
CAPACITY ADDITIONS, 1976-85
PLUS SCENARIO UNIT ADDITIONS, 1986-2000


3000. - 5400.
2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Planned additions)
2 Number of scenario unit additions

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY CAGIS UICC AUGUST, 1975

FIGURE 4-7. COAL-FIRED CAPACITY ADDITIONS FOR SCENARIO 2

SCENARIO 2a:
CONVENTIONAL TECHNOLOGY, BASE CASE CONTROLS, COAL-FIRED EXPORT
TOTAL PROPOSED COAL-FIRED GENERATING
CAPACITY ADDITIONS, 1976-85
PLUS SCENARIO UNIT ADDITIONS, 1986-2000


3000. - 5400.
2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Planned additions)
2 Number of scenario unit additions
② Circled numbers include units for export

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY CASIS UICC AUGUST, 1975

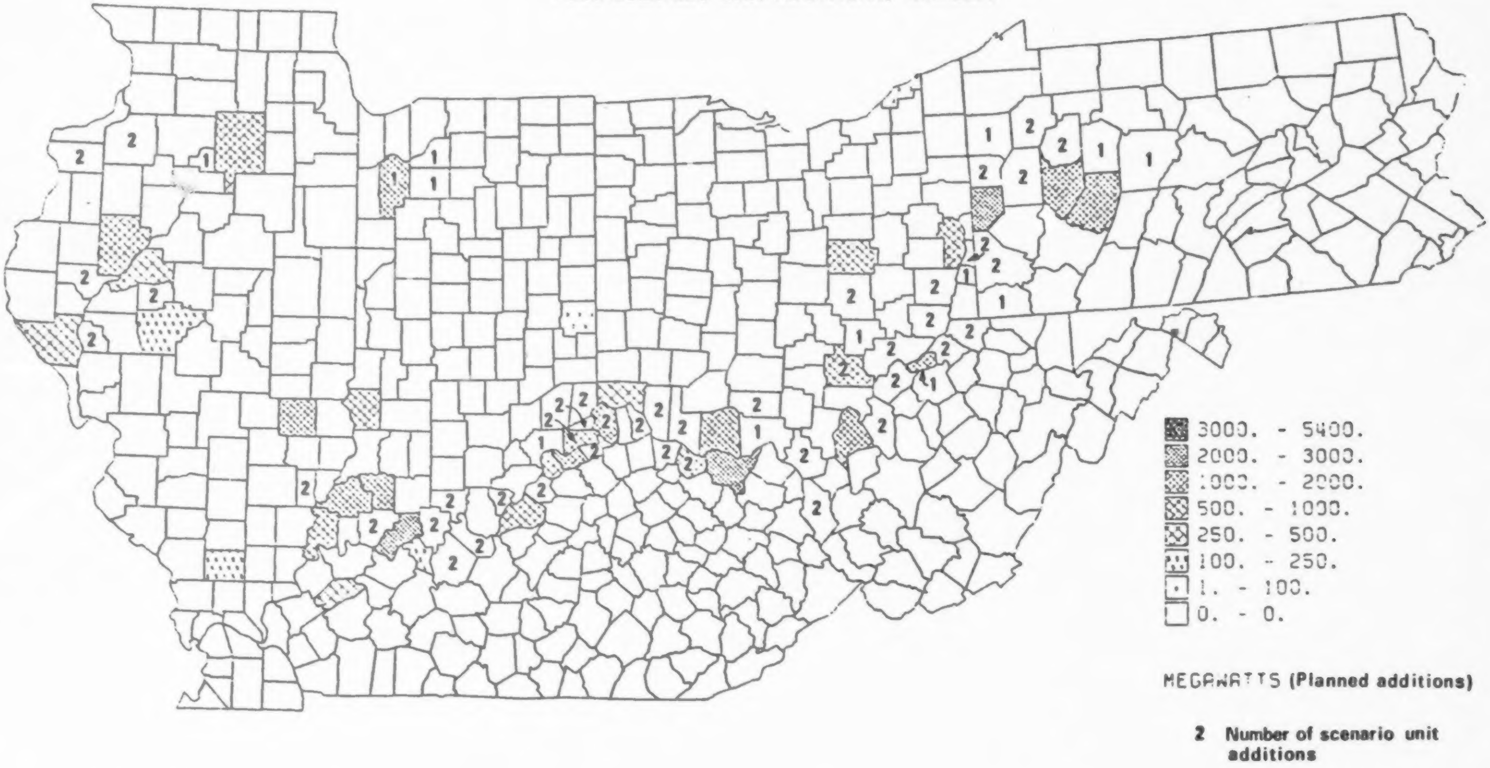
FIGURE 4-8. COAL-FIRED CAPACITY ADDITIONS FOR SCENARIO 2a

SCENARIO 2b:

CONVENTIONAL TECHNOLOGY, BASE CASE CONTROLS, NUCLEAR-FUELED EXPORT

TOTAL PROPOSED COAL-FIRED GENERATING
CAPACITY ADDITIONS, 1976-85

PLUS SCENARIO UNIT ADDITIONS, 1986-2000


3000. - 5400.
2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Planned additions)
2 Number of scenario unit additions
1
2

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY CAGIS UICC AUGUST, 1975

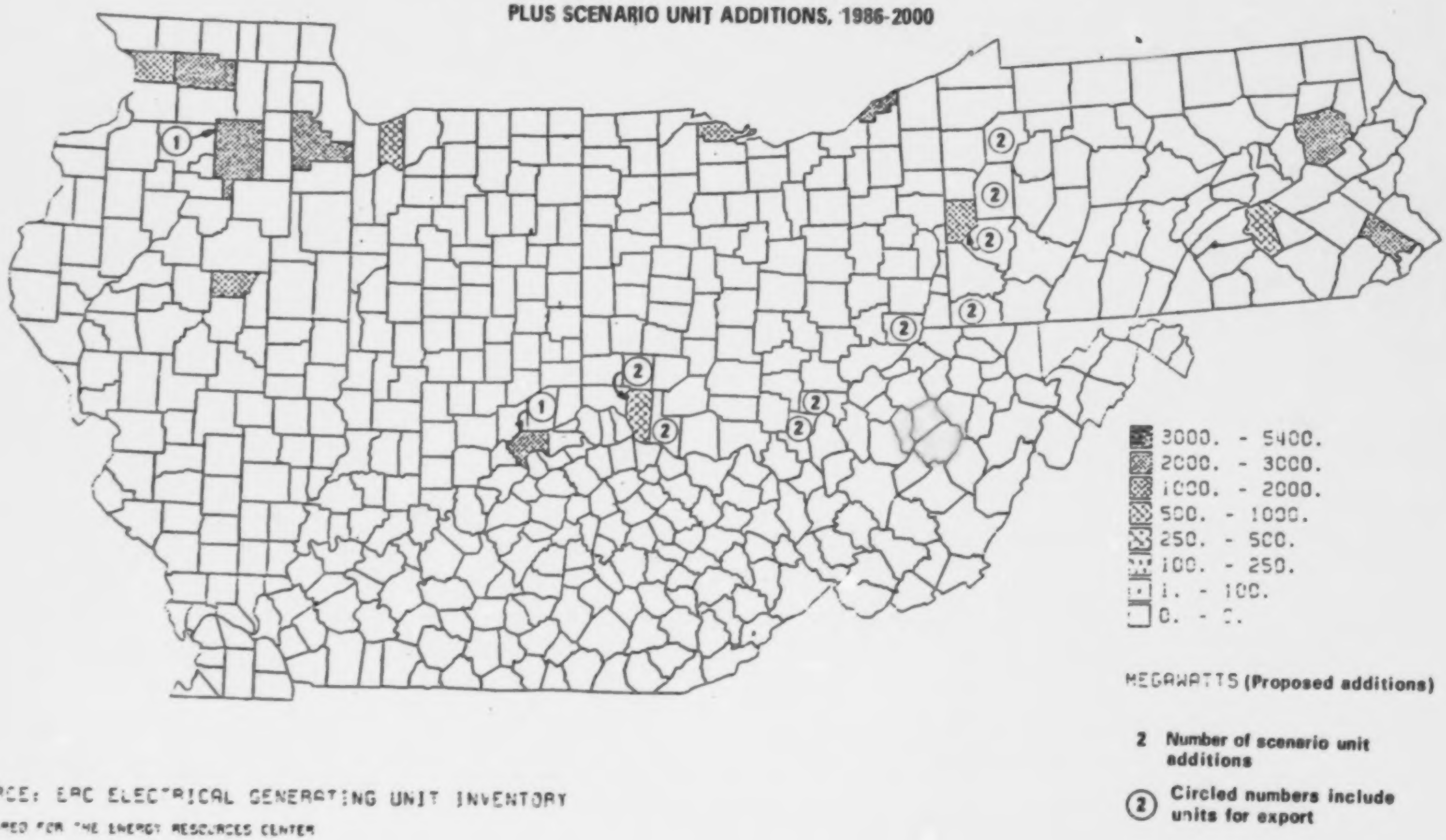
FIGURE 4-9. COAL-FIRED CAPACITY ADDITIONS FOR SCENARIO 2b

SCENARIO 2b:

CONVENTIONAL TECHNOLOGY, BASE CASE CONTROLS, NUCLEAR-FUELED EXPORT

TOTAL PROPOSED NUCLEAR GENERATING
CAPACITY ADDITIONS, 1976-85

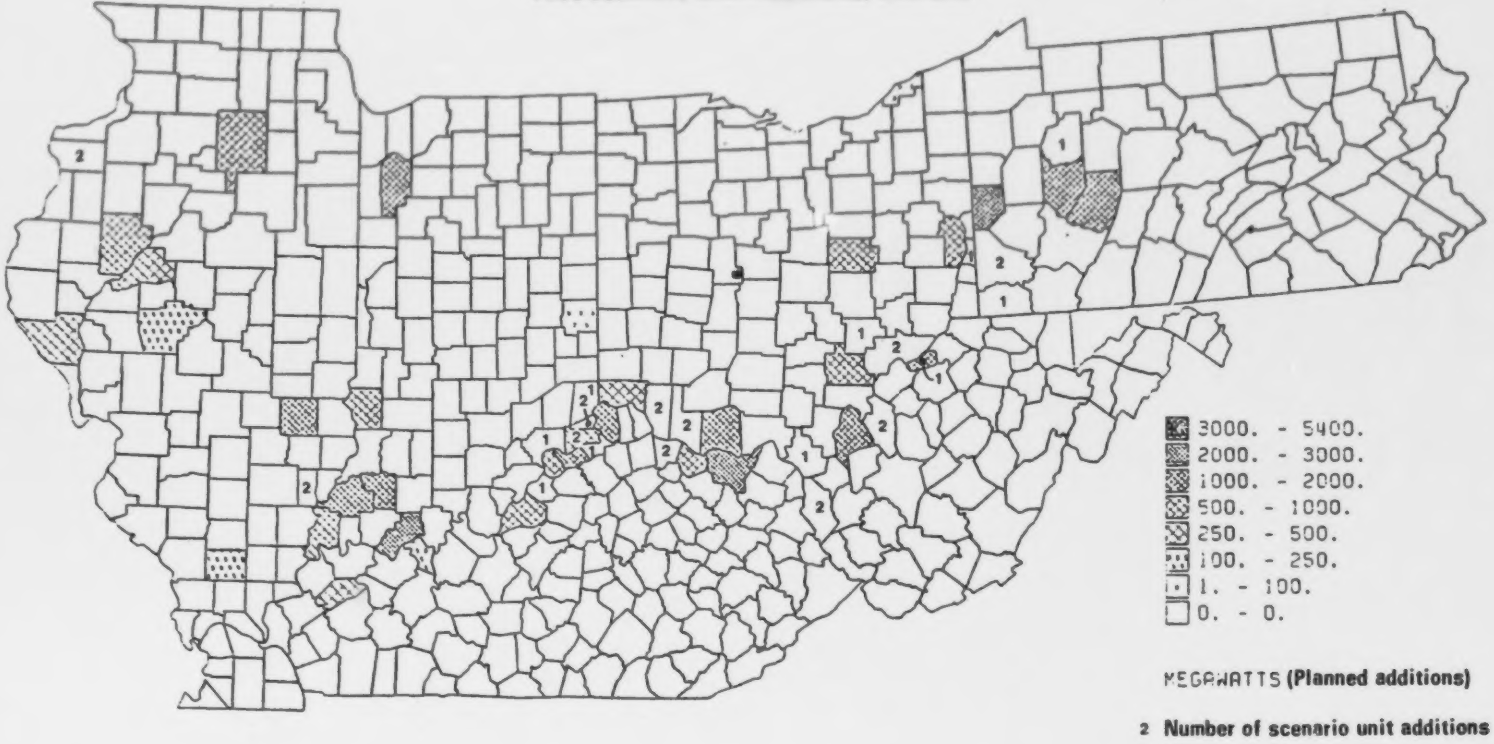
PLUS SCENARIO UNIT ADDITIONS, 1986-2000


①
②
3000. - 5400.
2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Proposed additions)
2 Number of scenario unit additions
② Circled numbers include units for export

SOURCE: EAC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY [illegible] AUGUST, 1979

FIGURE 4-10. NUCLEAR-FUELED CAPACITY ADDITIONS FOR SCENARIO 2b

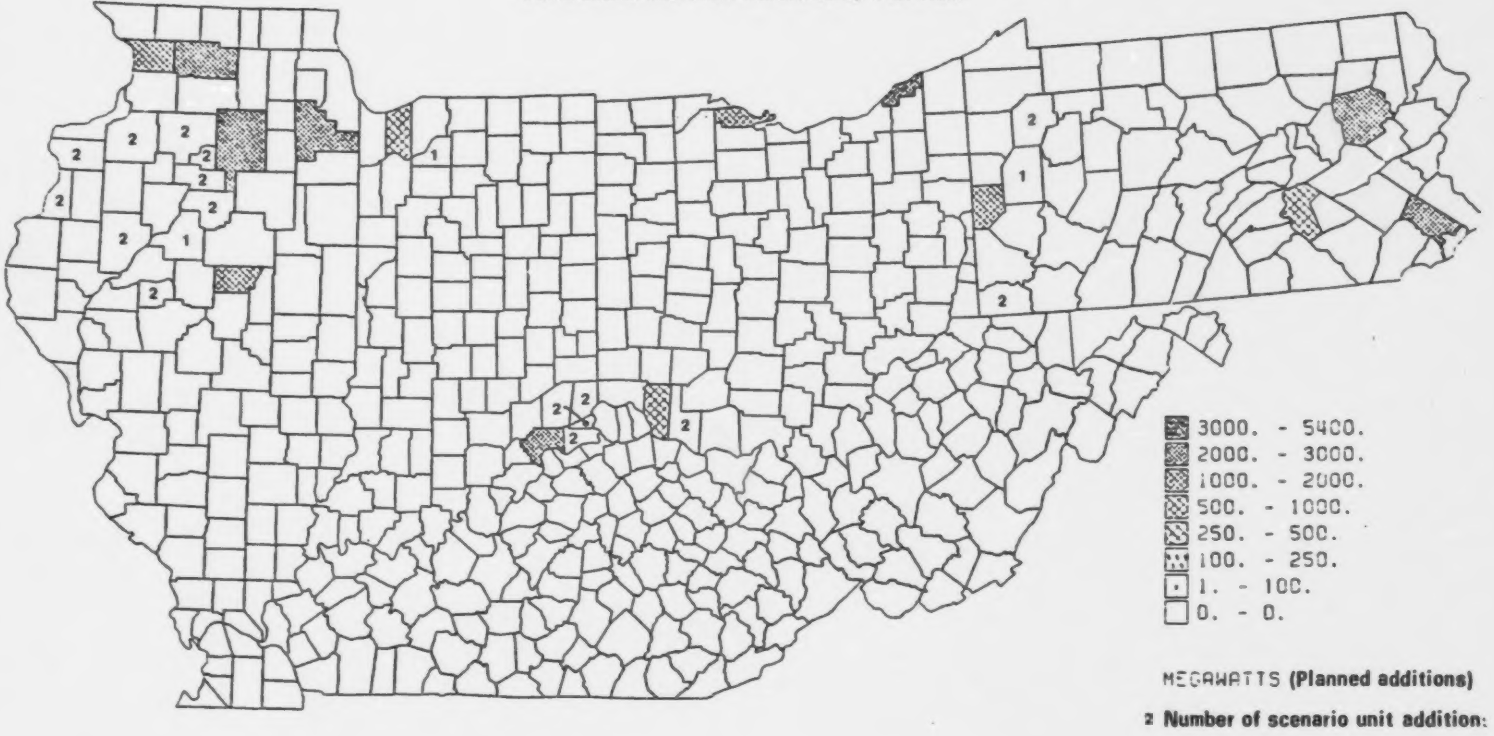
SCENARIO 2c:
CONVENTIONAL TECHNOLOGY, BASE CASE CONTROLS, NUCLEAR EMPHASIS
TOTAL PROPOSED COAL-FIRED-GENERATING
CAPACITY ADDITIONS, 1976-85
PLUS SCENARIO UNIT ADDITIONS, 1986-2000


3000. - 5400.
2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Planned additions)
2 Number of scenario unit additions
1
2

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY CAGIS UICC AUGUST, 1975

FIGURE 4-11. COAL-FIRED CAPACITY ADDITIONS FOR SCENARIO 2c

SCENARIO 2c:
CONVENTIONAL TECHNOLOGY, BASE CASE CONTROLS, NUCLEAR EMPHASIS
TOTAL PROPOSED NUCLEAR GENERATING
CAPACITY ADDITIONS, 1976-85
PLUS SCENARIO UNIT ADDITIONS, 1986-2000


3000. - 5400.
2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Planned additions)
2 Number of scenario unit addition:
2
1

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY CAGIS UICC, AUGUST, 1975

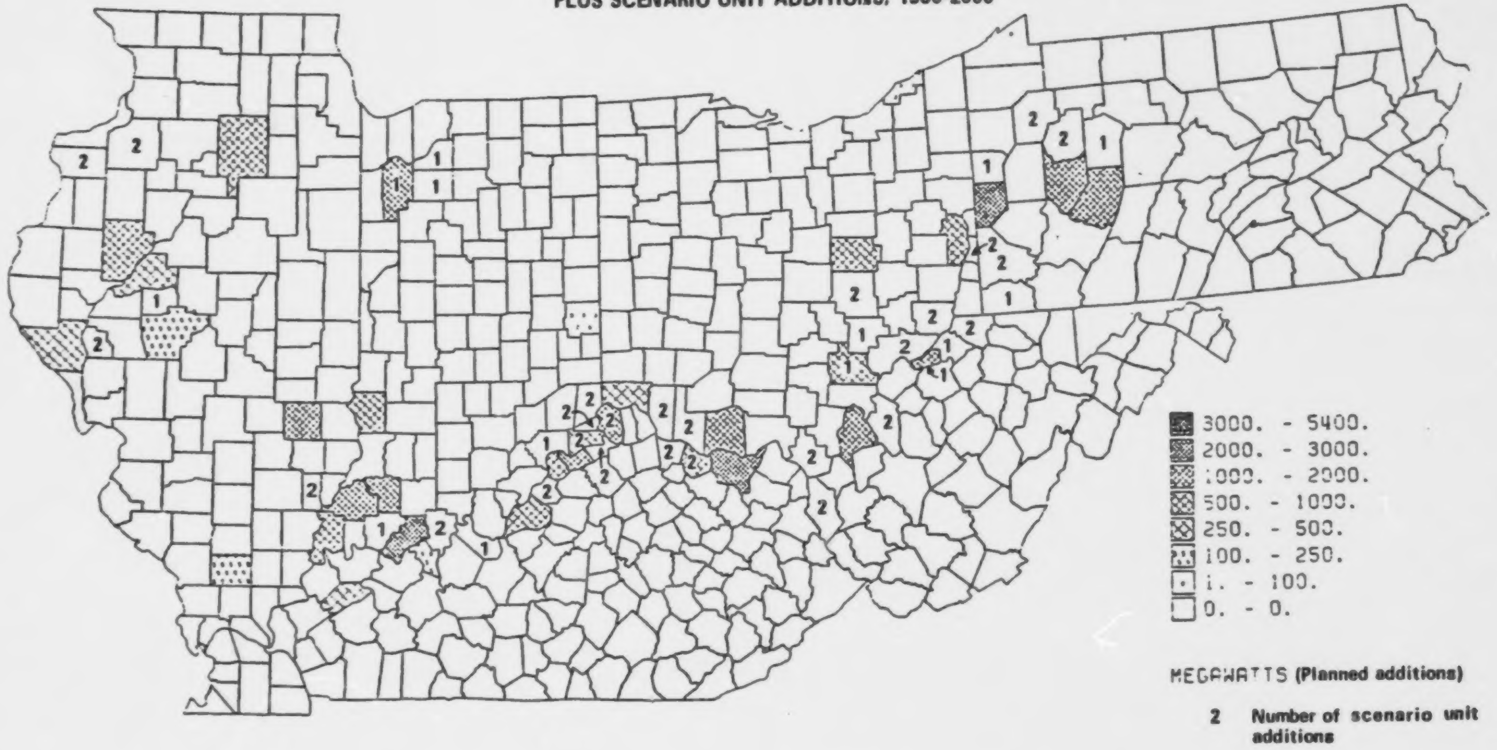
FIGURE 4-12. NUCLEAR-FUELED CAPACITY ADDITIONS FOR SCENARIO 2c

SCENARIO 3:

ALTERNATE TECHNOLOGY, BASE CASE CONTROLS

TOTAL PROPOSED COAL-FIRED GENERATING
CAPACITY ADDITIONS, 1976-85

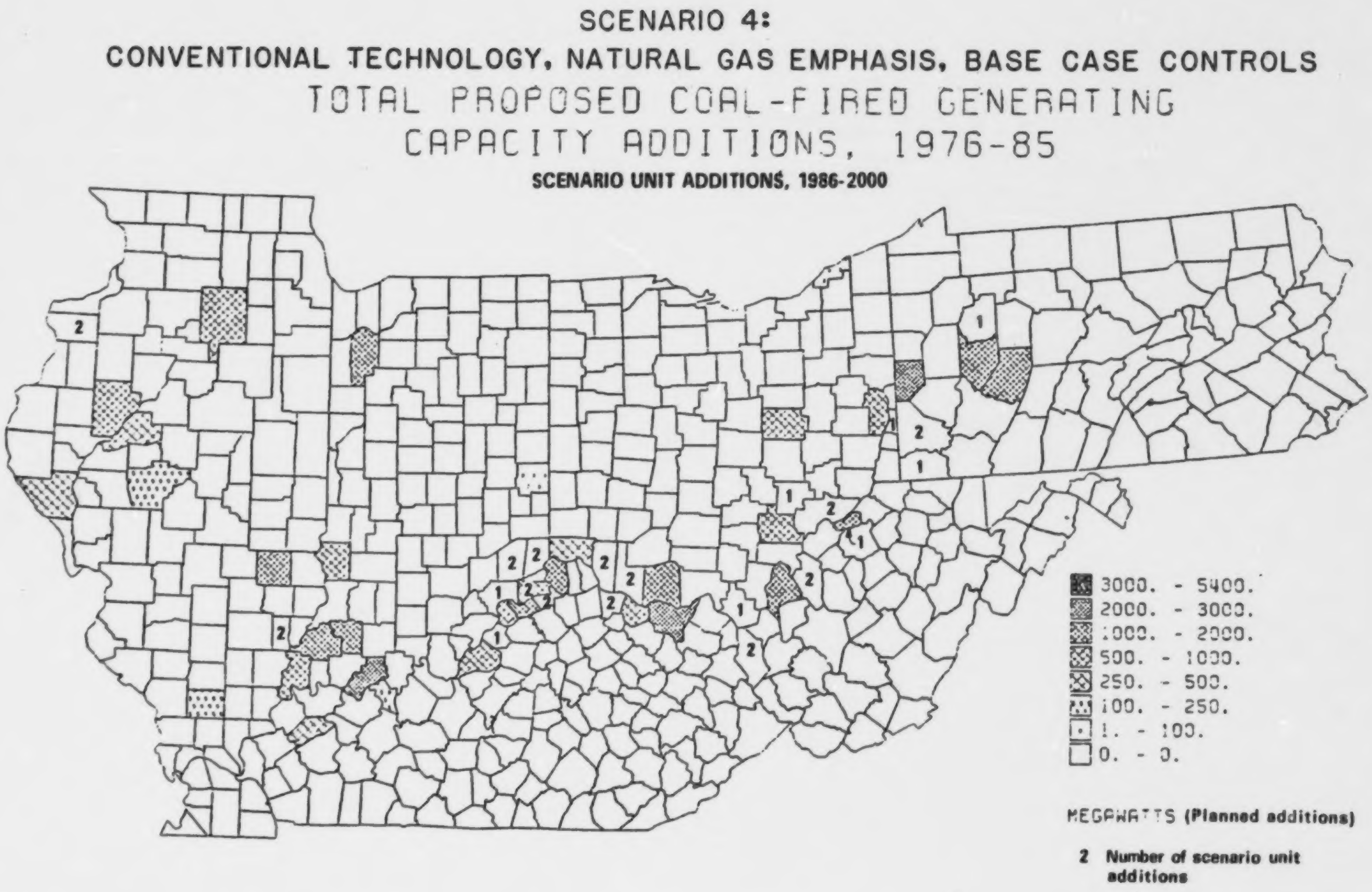
PLUS SCENARIO UNIT ADDITIONS, 1986-2000



3000. - 5400.
2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Planned additions)
2 Number of scenario unit additions

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY CAGIS UICC AUGUST, 1975

FIGURE 4-13. COAL-FIRED CAPACITY ADDITIONS FOR SCENARIO 3


SCENARIO 4:
CONVENTIONAL TECHNOLOGY, NATURAL GAS EMPHASIS, BASE CASE CONTROLS
TOTAL PROPOSED COAL-FIRED GENERATING
CAPACITY ADDITIONS, 1976-85
SCENARIO UNIT ADDITIONS, 1986-2000
3000. - 5400.
2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Planned additions)
2 Number of scenario unit additions
1
2

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY CAGIS UICC AUGUST, 1975

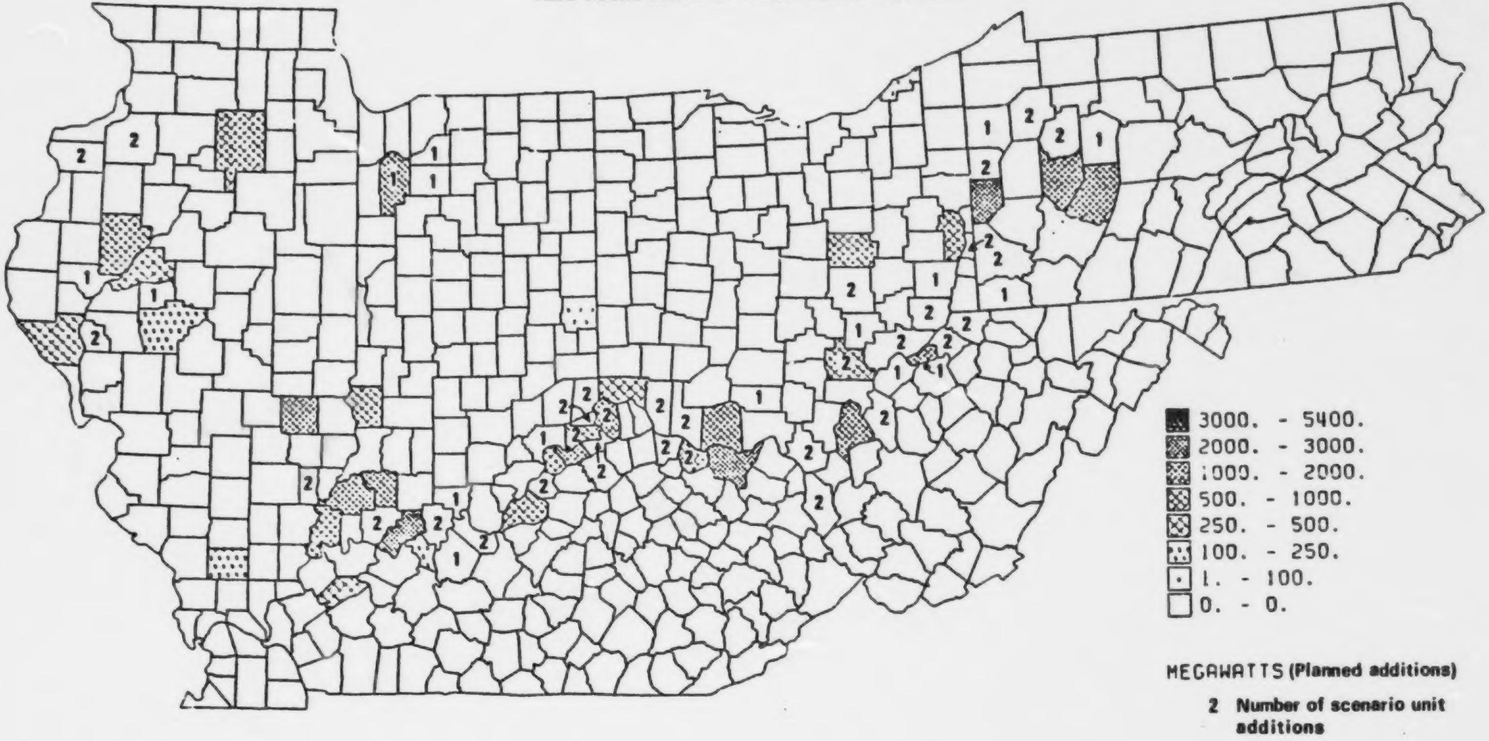
FIGURE 4-14. COAL-FIRED CAPACITY ADDITIONS FOR SCENARIO 4

SCENARIO 5:

CONVENTIONAL TECHNOLOGY, BASE CASE CONTROLS, LOW ECONOMIC GROWTH

TOTAL PROPOSED COAL-FIRED GENERATING CAPACITY ADDITIONS, 1976-85

PLUS SCENARIO UNIT ADDITIONS, 1986-2000


3000. - 5400.
2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Planned additions)
2 Number of scenario unit additions

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY

PREPARED FOR THE ENERGY RESOURCES CENTER

BY CAGIS UICC AUGUST, 1979

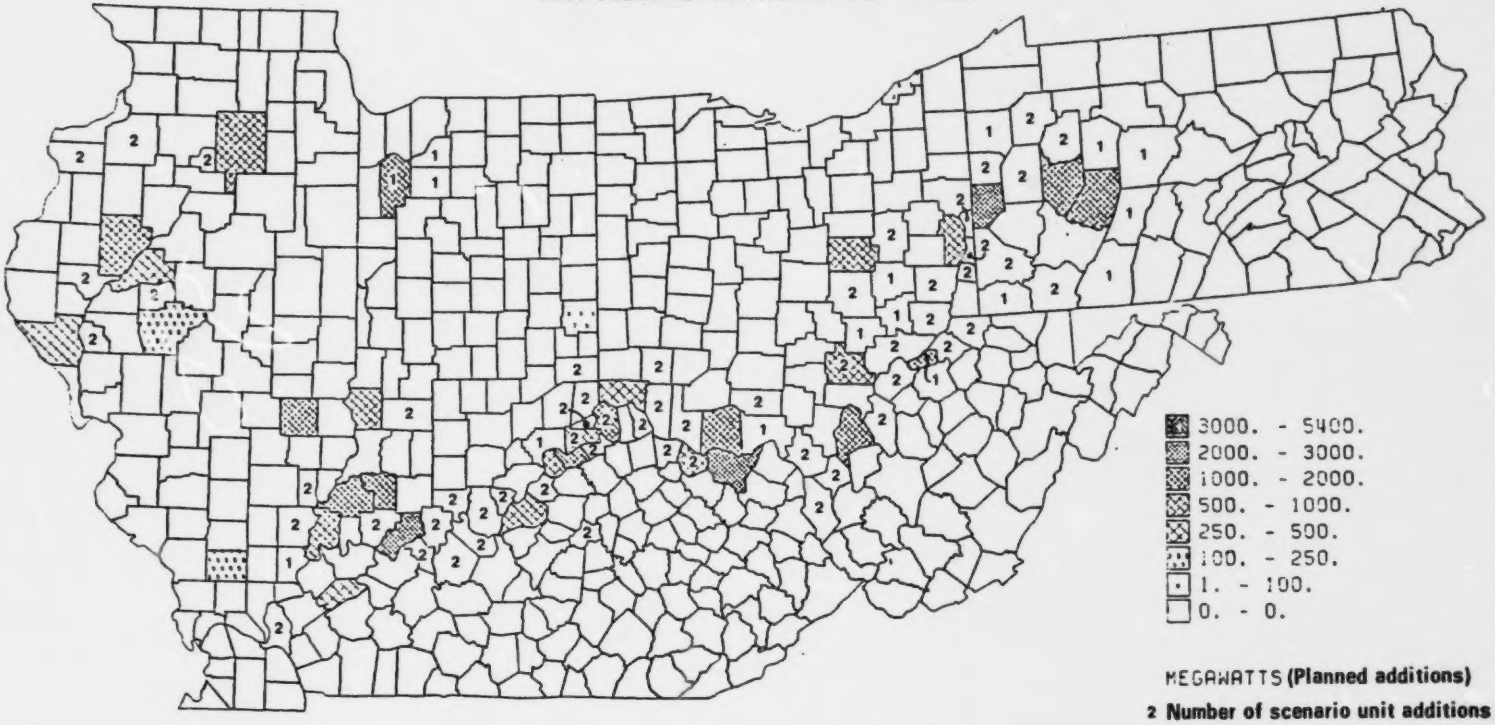
FIGURE 4-15. COAL-FIRED CAPACITY ADDITIONS FOR SCENARIO 5

SCENARIO 5a:

CONVENTIONAL TECHNOLOGY, BASE CASE CONTROLS, VERY HIGH ECONOMIC GROWTH

TOTAL PROPOSED COAL-FIRED GENERATING
CAPACITY ADDITIONS, 1976-85

PLUS SCENARIO UNIT ADDITIONS, 1986-2000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2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Planned additions)
2 Number of scenario unit additions
1
2

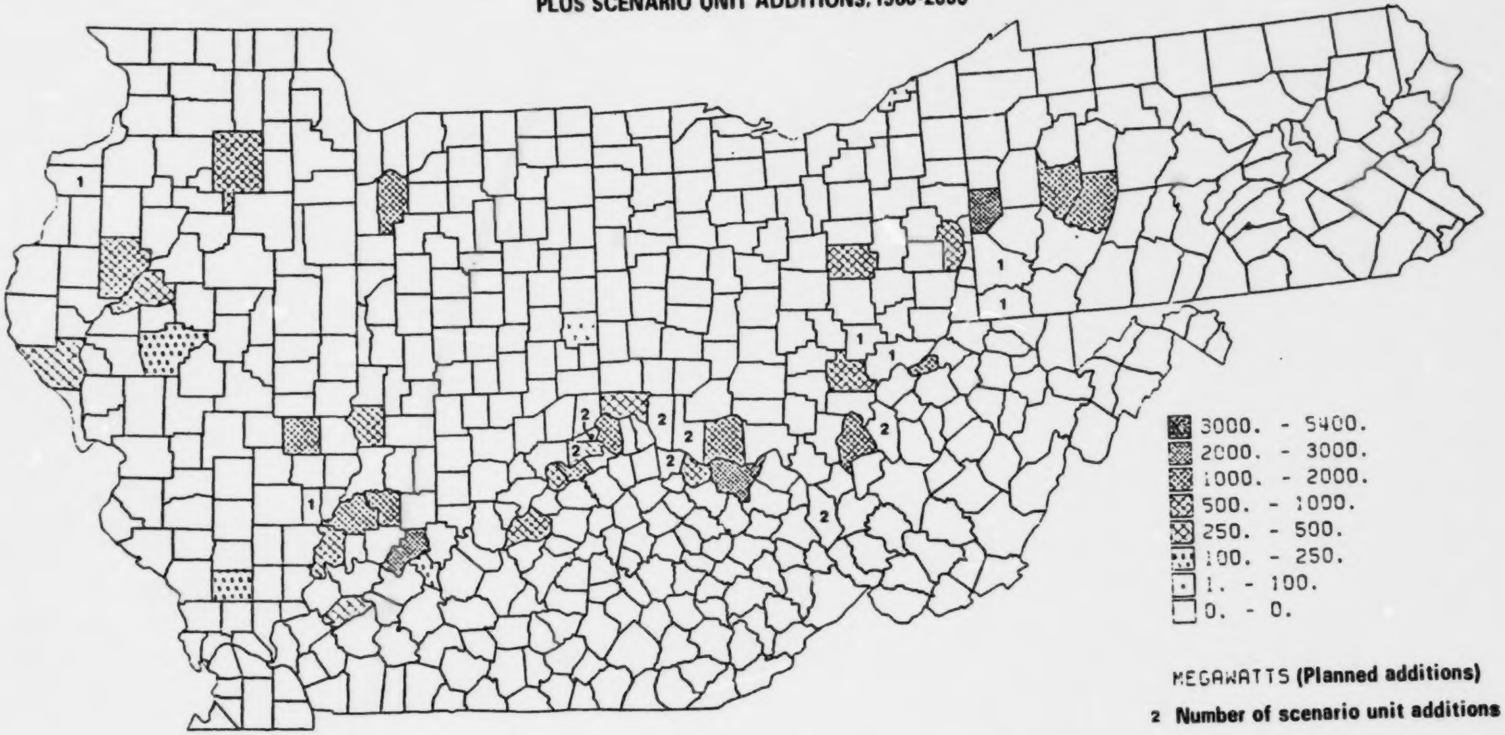
SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY

PREPARED FOR THE ENERGY RESOURCES CENTER

BY CAGIS UICC AUGUST, 1975

FIGURE 4-16. COAL-FIRED CAPACITY ADDITIONS FOR SCENARIO 5a

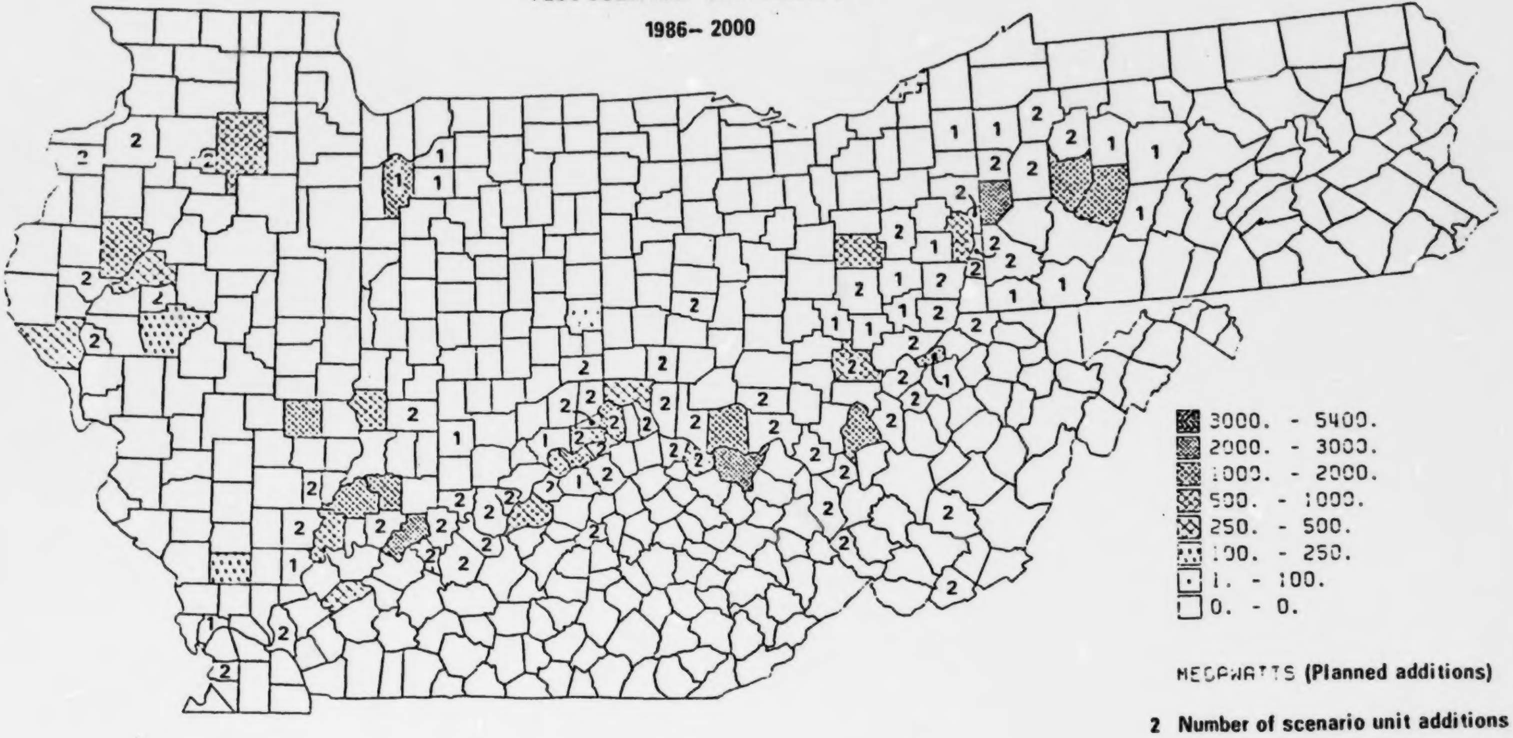
SCENARIO 6:
CONVENTIONAL TECHNOLOGY, BASE CASE CONTROLS, VERY LOW ENERGY GROWTH
TOTAL PROPOSED COAL-FIRED-GENERATING
CAPACITY ADDITIONS, 1976-85
PLUS SCENARIO UNIT ADDITIONS, 1986-2000


1
1
1
1
1
1
2
2
2
2
2
2
2
2
3000. - 5400.
2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Planned additions)
2 Number of scenario unit additions

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY CAGIS UICC AUGUST, 1975

FIGURE 4-17. COAL-FIRED CAPACITY ADDITIONS FOR SCENARIO 6

SCENARIO 7:
CONVENTIONAL COAL EMPHASIS, BASE CASE, HIGH ELECTRICAL ENERGY GROWTH
TOTAL PROPOSED COAL-FIRED GENERATING
CAPACITY ADDITIONS, 1976-85
PLUS SCENARIO UNIT ADDITIONS
1986– 2000


3000. - 5400.
2000. - 3000.
1000. - 2000.
500. - 1000.
250. - 500.
100. - 250.
1. - 100.
0. - 0.
MEGAWATTS (Planned additions)
2 Number of scenario unit additions

SOURCE: ERC ELECTRICAL GENERATING UNIT INVENTORY
PREPARED FOR THE ENERGY RESOURCES CENTER
BY CAGIS UICC AUGUST, 1975

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FIGURE 4-18. COAL-FIRED CAPACITY ADDITIONS FOR SCENARIO 7

TABLE 4-1. SUMMARY OF PLANNED AND SCENARIO CAPACITY ADDITIONS FOR THE ORBES STATE PORTIONS FOR ALL SCENARIOS

$\frac{8}{4{,}399} = \frac{\text{no. of counties sited in}}{\text{coal-fired megawatts}}$

(4,056) = nuclear-fueled megawatts

SCENARIO	STATES					
	Illinois	Indiana	Kentucky	Ohio	Pennsylvania	West Virginia
PLANNED						
All Scenarios	8/4,399 (4,056)	9/8,951 (2,260)	8/8,880	6/3,927 (810)	3/5,504 (1,830)	2/2,552
SCENARIO ADDITIONS						
1	7/8,450	12/11,700	8/10,400	18/13,000	8/9,100	9/9,100
1a	7/8,450	11/11,700	12/10,400	17/13,000	8/9,100	10/9,100
1b	4/8,450	5/11,700	4/10,400	8/13,000	4/9,100	4/9,100
1c	7/8,450	11/11,700	15/10,400	6/5,200[a]	8/9,100	9/16,900
1d	4/8,450	5/11,700	7/10,400	6/10,400[b]	4/11,050	4/9,100
2	7/8,450	11/11,700	8/10,400	10/13,000	9/9,100	8/9,100
2a	7/8,450	11/11,700	8/11,700	12/21,450	9/12,350	8/16,250
2b	8/8,450 (1,000)	11/11,700 (1,000)	8/10,400[c]	13/13,000 (10,000)	10/9,100 (8,000)	8/9,100[c]
2c	11/2,600 (19,000)	5/3,900 (7,000)	3/2,600[c]	5/5,200 (2,000)	5/2,600 (5,000)	4/3,900[c]
3	5/5,850	9/8,450	6/7,150	8/9,100	6/5,850	6/6,500
4	2/2,600	4/4,550	3/3,250	5/5,200	4/2,600	3/3,900
5	6/6,500	10/9,750	7/8,450	10/11,050	7/7,150	7/7,800
5a	9/11,050	14/15,600	11/14,300	15/16,900	12/11,700	10/12,350
6	2/1,300	2/2,600	1/1,300	4/3,900	2/1,300	2/2,600
7	10/11,700	15/16,250	14/18,200	19/20,800	11/10,400	13/16,250

[a] Twelve Ohio units sited in West Virginia due to lack of suitable Ohio sites.
[b] Four Ohio units sited in West Virginia due to lack of suitable Ohio sites.
[c] No nuclear-fueled facilities were sited in Kentucky or West Virginia consistent with prevailing nuclear energy policies in those states.

TABLE 4-2. SUMMARY OF TOTAL CAPACITY ADDITIONS FOR THE ORBES STATES PORTIONS FOR ALL SCENARIOS

$$\frac{15}{12,849} = \frac{\text{no. of counties sited in}}{\text{total coal-fired megawatts}}$$

(4,056) = total nuclear-fueled megawatts

SCENARIO	STATES						TOTAL
	Illinois	Indiana	Kentucky	Ohio	Pennsylvania	West Virginia	
1	15/12,849 (4,056)	18/20,651 (2,260)	14/19,280	24/16,927 (810)	11/14,604 (1,830)	10/11,652	92/77,373 (8,956)
1a	15/12,849 (4,056)	17/20,651 (2,260)	20/19,280	24/16,927 (810)	11/14,604 (1,830)	11/11,652	98/77,373 (8,956)
1b	12/12,849 (4,056)	11/20,651 (2,260)	12/19,280	15/16,927 (810)	7/14,604 (1,830)	5/11,652	62/77,373 (8,956)
1c	14/12,849 (4,056)	18/20,651 (2,260)	23/19,280	13/9,127 (810)	11/14,604 (1,830)	11/19,452	90/95,963 (8,956)
1d	12/12,849 (4,056)	12/20,651 (2,260)	15/19,280	13/14,227 (810)	7/16,554 (1,830)	6/19,452	65/103,078 (8,956)
2	15/12,849 (4,056)	17/20,651 (2,260)	14/19,280	15/16,927 (810)	12/14,604 (1,830)	10/11,652	83/95,963 (8,956)
2a	15/12,849 (4,056)	17/20,651 (2,260)	14/20,580	16/25,377 (810)	12/17,854 (1,830)	9/18,802	83/116,196 (8,956)
2b	16/12,849 (5,056)	17/20,651 (3,260)	14/19,280	18/16,927 (10,810)	13/14,604 (9,830)	9/11,652	87/95,963 (28,956)
2c	18/6,999 (23,056)	12/12,851 (9,260)	11/11,480	10/9,127 (2,810)	8/8,104 (6,830)	5/6,452	64/55,013 (41,956)
3	13/10,249 (4,056)	15/17,401 (2,260)	12/16,030	12/13,027 (810)	9/11,354 (1,830)	7/9,052	68/77,113 (8,956)
4	10/6,999 (4,056)	11/13,501 (2,260)	11/12,130	10/9,127 (810)	7/8,104 (1,830)	4/6,452	53/56,313 (8,956)
5	14/10,899 (4,056)	16/18,701 (2,260)	13/17,330	13/14,977 (810)	10/12,654 (1,830)	8/10,352	74/84,913 (8,956)
5a	17/15,449 (4,056)	20/24,551 (2,260)	17/23,180	18/20,827 (810)	15/17,204 (1,830)	11/14,902	98/116,113 (8,956)
6	10/5,699 (4,056)	10/11,551 (2,260)	9/10,180	9/7,827 (810)	5/6,804 (1,830)	4/5,152	47/47,213 (8,956)
7	18/16,099 (4,056)	21/18,510 (2,260)	20/27,080	22/24,727 (810)	14/15,904 (1,830)	14/18,802	109/121,122 (8,956)

SECTION 5

IMPACT ASSESSMENT

5.1 APPROACH

The overall approach taken for the analysis of land quality and terrestrial ecosystems is shown in Figure 5-1. A major problem with these analyses is the very heterogeneous data base. The analyses discussed here are very simplistic approaches to examining the complexity of variables useful to understanding the quality and human use of terrestrial ecosystems. Questions concerning the geography of possible energy facilities are also directly relevant to the questions of land quality and use. Thus, as Figure 5-1 indicates, the ORBES linear weighting siting model (discussed fully in Section 4.0), the land quality data and analysis (see Section 2.1), and information concerning the terrestrial ecology of the ORBES region (Section 2.2) are highly interrelated. There are four fundamental steps in the impact assessment process: (1) development of some reasonably homogeneous, representative, region-wide data base; (2) development of the scenarios and the siting model to project the number of facilities, their potential locations, and their construction schedule; (3) development of standardized model facilities; and (4) integration of the preceding three steps. Steps 1 and 2 were discussed previously. Steps 3 and 4 will be addressed here.

5.2 LAND USE

In order to assess the impacts of the ORBES energy scenarios on land use, current land use conversion by the three major energy land use conversion categories must be determined. These categories are: (1) electrical generating facilities, (2) transmission line rights-of-way, and (3) surface coal mines. For each of these categories, average land use conversion rates were calculated for the "standard" electrical generating facility sited in the scenarios. The calculated rates were then used in assessing the land use conversion impacts of the 15 siting configurations.

Land Use Converstion Due to Electrical Generating Facilities

Land use requirements for the planned and scenario addition facilities were estimated from those of six planned facilities in the ORBES region (Table 5-1). The average land ownership at the six facilities studied was 1,100 acres per 650 MWe generating capacity. Of this, 400 acres of land were directly impacted and 700 acres were not directly impacted.

Areas directly impacted by a facility were considered to have undergone an irreversible land use conversion. These areas include buildings, fuel and waste storage areas, and associated roads at the construction site. Areas associated with a facility but not directly impacted by it were considered to have undergone a reversible land use conversion. For example, utility-owned lands at a facility site that are contiguous to but not included in the actual construction area were considered as not irreversibly impacted. The notion of irreversible and reversible land use conversion is often one of considerable debate. There are those who would argue that no land use

LAND QUALITY/TERRESTRIAL SYSTEMS IMPACT ANALYSIS

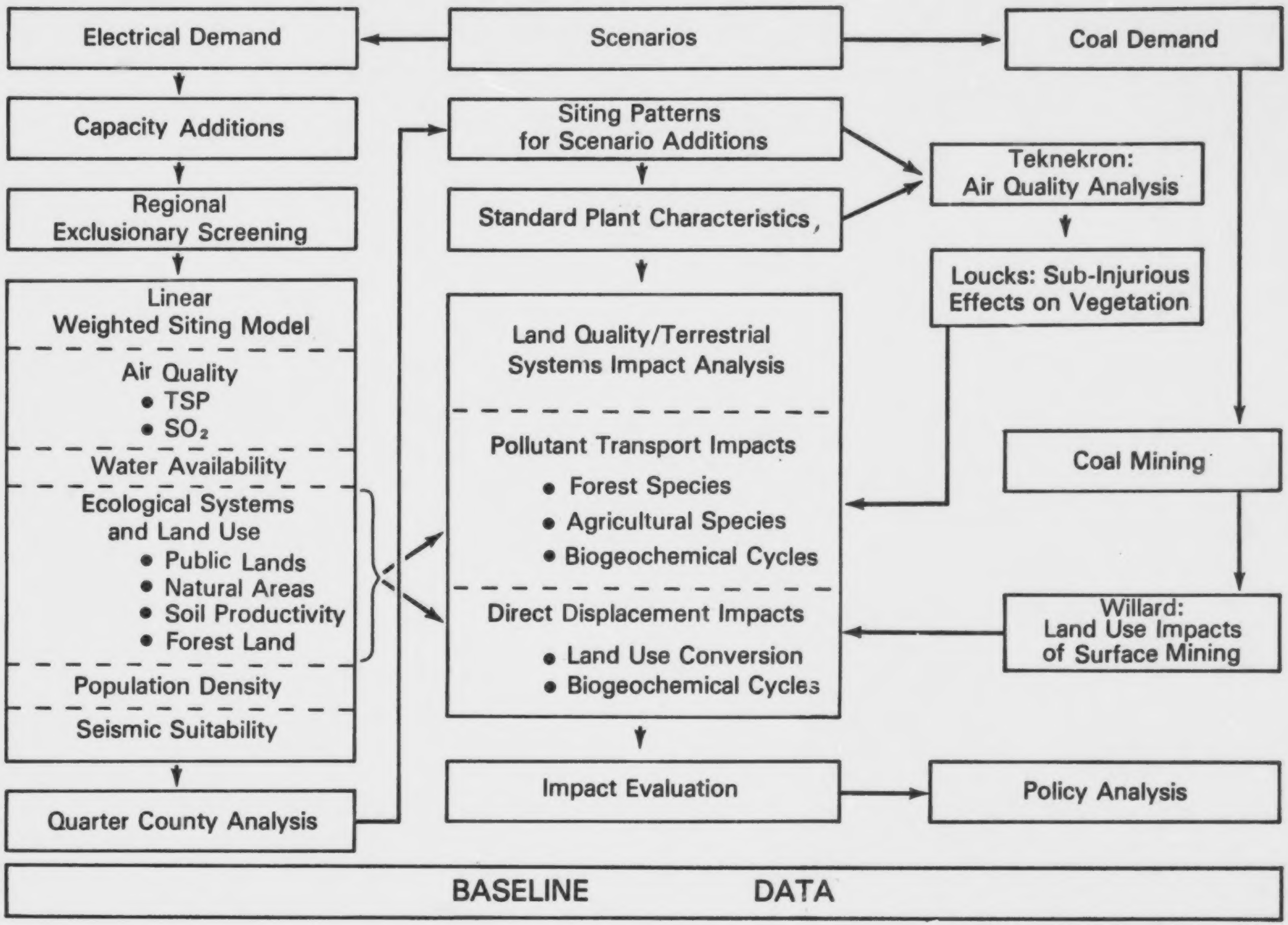

Electrical Demand
Scenarios
Coal Demand
Capacity Additions
Siting Patterns for Scenario Additions
Teknekron: Air Quality Analysis
Regional Exclusionary Screening
Standard Plant Characteristics,
Loucks: Sub-Injurious Effects on Vegetation
Linear Weighted Siting Model
Air Quality
• TSP
• SO₂
Water Availability
Ecological Systems and Land Use
• Public Lands
• Natural Areas
• Soil Productivity
• Forest Land
Population Density
Seismic Suitability
Land Quality/Terrestrial Systems Impact Analysis
Pollutant Transport Impacts
• Forest Species
• Agricultural Species
• Biogeochemical Cycles
Direct Displacement Impacts
• Land Use Conversion
• Biogeochemical Cycles
Coal Mining
Willard: Land Use Impacts of Surface Mining
Quarter County Analysis
Impact Evaluation
Policy Analysis
BASELINE DATA

FIGURE 5-1

TABLE 5-1. REPRESENTATIVE VALUES OF LAND REQUIREMENTS FOR VARIOUS COMPONENTS OF AN ELECTRICAL GENERATING STATION
(All Units Are Acres)

Facility	Total Land Owned at Site	Total Land Per 650 MWe	Land Impacted	Land Impacted Per 650 MWe
East Bend	1,777	960	600	323
Trimble Co.	2,300	644	1,844	511
Merom	2,650*	1,749	--	--
Rockport	3,820	955	1,970	493
Killen	1,750	946	650	350
Average	2,459	1,051	1,266	419

Cooling Ponds: 1-2 acres/MWe (coal)
2-4 acres/MWe (nuclear)

---

*Without cooling pond.

conversion is really completely irreversible. While that may be the case, the expense and time needed to reverse certain land uses would be so far beyond the time frame of this project as to be irrelevant. So, in the ORBES study, an irreversible land use is defined as one that is at least likely to exist for the normal life of a generating facility, and probably much longer.

Using these estimates of land requirements, present (1976) land use by energy conversion facilities in the ORBES region was calculated (Table 5-2). Land requirements ranged from 20,311 acres for Kentucky to 33,007 acres for Ohio. The total for the ORBES portion of the six states was 140,673 acres, while the sum of the state totals was 203,884 acres.

Because land uses at each of the planned or scenario addition facility sites are not discernible from U. S. Geological Survey topographic base maps, the proportion of land use categories (agricultural, forest, public, and other) potentially undergoing conversion at these sites was assumed to be the same as for the county in which the site was located (see Tables 2-1 through 2-6). Using the energy facility land use requirements presented in Table 5-1, reversible, irreversible, and total land use conversion by category was summed for each state for the 15 ORBES energy scenarios. Table 5-3 gives one example of the 90 detailed analyses performed in this way.

Tables 5-4 through 5-18 summarize the potential land use conversion within each state and for the ORBES region by major land use for each of 15 scenarios. Graphical summarizations of these results are given for each state in Figures 5-2 through 5-7 and for the ORBES region in Figures 5-8 through 5-10. Table 5-19 presents a summary of the maximum absolute values (acres) and relative values (percentage) of land use conversion for each major category by scenario.

Land Use Converstion From Transmission Lines

The amount of land required for transmission line rights-of-way (R-O-W) varies according to plant capacity, voltage carried, number of lines, and length of lines. Transmission line R-O-W account for the greatest amount of reversible land use conversion associated with energy conversion facilities. Average R-O-W widths range from 210 feet for 138 kV lines to 250 feet for 765 kV lines (Smith et al. 1977). Multiple line corridors can be from 500 to 1,000 feet wide (Kitchings et al. 1972). Nationally, a gross average of 13 acres is disturbed per mile of transmission line. The heights of transmission towers range from 55 to 140 feet (Smith et al. 1977).

There are approximately 300,000 miles of overhead high voltage transmission lines nationally which supply power from generating plants to substations. The rights-of-way for these lines require approximately 4,000,000 acres of land (Arner, 1977). The ORBES region share of national electrical generation in 1976 was 15 percent (Federal Energy Administration 1977; Jansen 1978; Hartnett and Saper 1979). A first approximation of the ORBES region share of existing transmission line R-O-W land use requirements can be made by assuming a direct proportionality between land use and electricity generated. This yields an approximation of 600,000 acres of land required for existing transmission line R-O-W in the ORBES region, or approximately 4,700 acres per 650 MWe generated.

TABLE 5-2. ESTIMATE OF PRESENT (1976) LAND USE BY ENERGY CONVERSION FACILITIES IN THE ORBES REGION

STATE	ORBES REGION		STATE TOTAL	
	Generating Capacity (MWe)[1]	Total Land Use (Acres)[2]	Generating Capacity (MWe)	Total Land Use (Acres)
Illinois	14,376	24,329	26,486	44,822
Indiana	12,322	20,853	15,989	27,058
Kentucky	12,002	20,311	12,002	20,311
Ohio	19,504	33,007	25,067	42,421
Pennsylvania	12,081	20,445	28,087	47,532
West Virginia	12,840	21,729	12,846	21,739
Total	83,125	140,673	120,477	203,884

[1] From Jansen, S. D. 1978. Electrical Generating Unit Inventory 1976-1986. Illinois, Indiana, Kentucky, Ohio, Pennsylvania and West Virginia. Energy Resources Center, University of Illinois at Chicago Circle, Chicago.

[2] Based on an estimate of 1,100 acres per 650 MWe site.

TABLE 5-3. DETAILED ANALYSIS OF POTENTIAL LAND USE CONVERSIONS BY MAJOR CATEGORY IN KENTUCKY FOR SCENARIO 1 (COAL, CONVENTIONAL TECHNOLOGY, STRICT CONTROLS, HIGH GROWTH). ONE EXAMPLE OF THE 90 ANALYSES CONDUCTED.

Scenario 1 State Kentucky County	Capacity (MWe) Planned Additions and Scenario Additions (XXX = nuclear)	County Capacity (MWe)	0.066 ppm 20_2 Air Impact Zone (0.3 acres MWe^{-1})	% Public Lands	% Ag. Lands	% Forest Lands	% Other Lands	Total Direct Land Impact (1.69 acres MWe^{-1})	Acres Public Lands	Acres Ag. Lands	Acres Forest Lands	Acres Other Lands	Irreversibly Impacted Land (0.62 acres MWe^{-1}) (37% of total)	Acres Public Lands	Acres Ag. Lands	Acres Forest Lands	Acres Other Lands	Reversibly Impacted Land (1.08 acres MWe^{-1}) (63% of total)	Acres Public Lands	Acres Ag. Lands	Acres Forest Lands	Acres Other Lands
1985																						
Carroll	550,550,550	1650	495	1	59	32	8	2789	28	1646	892	223	1023	10	604	327	82	1782	18	1051	570	143
Mason	300, 500	800	240	0	84	12	4	1352	0	1136	162	54	496	0	417	60	20	864	0	726	104	35
Jefferson	425	425	128	1	42	14	43	718	7	302	101	309	264	3	111	37	114	459	5	193	64	197
Webster	240, 240	480	144	0	61	31	8	811	0	495	251	65	298	0	182	92	24	518	0	316	161	41
Boone	600, 600	1200	360	1	65	27	7	2028	20	1318	548	142	744	7	484	201	52	1296	13	842	350	91
Trimble	495,495,495	1485	446	0	59	37	4	2510	0	1481	929	100	921	0	543	341	37	1604	0	946	593	64
Lewis	1300, 1300	2600	780	2	20	76	2	4394	88	879	3339	88	1612	32	322	1225	32	2808	56	562	2134	56
Hancock	240	240	72	0	47	47	6	406	0	191	191	24	149	0	70	70	9	259	0	122	122	16
Sub-Total	8800	8800	2665					15008	143	7448	6413	1005	5507	52	2733	2353	370	9590	92	4758	4098	643
2000																						
Bracken	650, 650	1300	390	0	66	30	4	2197	0	1450	659	88	806	0	532	242	32	1404	0	927	421	56
Boone	800,650,650	2100	630	1	65	27	7	3549	35	2307	958	248	1302	13	846	352	91	2268	23	1474	612	150
Trimble	675, 675	1350	405	0	59	37	4	2282	0	1346	844	91	837	0	494	310	33	1458	0	860	539	58
Gallatin	650, 650	1300	390	0	65	30	5	2197	0	1428	659	110	806	0	524	242	40	1404	0	913	421	70
Oldham	650, 650	1300	390	1	70	19	10	2197	22	1538	417	220	806	8	564	153	81	1404	14	983	267	140
Mason	650, 650	1300	390	0	84	12	4	2197	0	1845	264	88	806	0	677	97	32	1404	0	1179	168	56
Meade	650, 650	1300	390	2	48	39	11	2197	44	1055	857	242	806	16	387	314	89	1404	28	674	548	154
Breckinridge	650, 650	1300	390	2	50	44	4	2197	44	1099	967	88	806	16	403	355	32	1404	28	702	618	56
Anderson	650	650	195	0	69	26	5	1099	0	758	286	55	403	0	278	105	20	702	0	484	183	35
Henry	650	650	195	0	70	24	6	1099	0	769	264	66	403	0	282	97	24	702	0	491	168	42
Sub-Total	12550	12550	3765					21211	145	13595	6175	1296	7781	53	4987	2267	474	13554	93	8687	3945	826
GRAND TOTAL	**21350**	**21350**	**6430**					**36219**	**288**	**21043**	**12588**	**2301**	**13288**	**105**	**7720**	**4620**	**844**	**23144**	**185**	**13445**	**8043**	**1469**

TABLE 5-4 POTENTIAL LAND USE CONVERSION BY MAJOR CATEGORY FOR SCENARIO 1 (Conventional Technology, Strict Controls). (All units are acres).

Location and Major Land Use Category	Irreversible Commitment of Land Resources 1985	Irreversible Commitment of Land Resources 2000	Reversible Commitment of Land Resources 1985	Reversible Commitment of Land Resources 2000	Total Land Use Conversion Through 2000	% of Total
Illinois						
Public lands	78	81	135	139	433	1
Ag. lands	4,380	4,754	7,459	8,098	24,691	80
Forest lands	471	770	800	1,312	3,353	11
Other lands	357	471	609	803	2,240	8
Totals	5,286	6,076	9,003	10,352	30,717	100
Indiana						
Public lands	240	148	416	260	1,064	3
Ag. lands	4,808	4,869	8,376	8,481	26,534	65
Forest lands	1,549	2,130	2,698	3,710	10,087	25
Other lands	354	724	616	1,264	2,958	7
Totals	6,951	7,871	12,106	13,715	40,643	100
Ohio						
Public lands	108	216	188	379	891	3
Ag. lands	1,133	5,530	1,973	9,638	18,274	58
Forest lands	1,276	2,225	2,222	3,878	9,601	30
Other lands	419	609	732	1,017	2,777	9
Totals	2,936	8,580	5,115	14,912	31,543	100
Kentucky						
Public lands	52	53	92	93	290	1
Ag. lands	2,733	4,987	4,758	8,687	21,165	58
Forest lands	2,353	2,267	4,098	3,945	12,663	35
Other lands	370	474	643	826	2,313	6
Totals	5,508	7,781	9,591	13,551	36,431	100
West Virginia						
Public lands	40	108	70	189	407	2
Ag. lands	383	999	667	1,741	3,790	19
Forest lands	1,120	4,208	1,950	7,330	14,608	74
Other lands	39	325	68	568	1,000	5
Totals	1,582	5,640	2,755	9,828	19,805	100
Pennsylvania						
Public lands	112	407	194	707	1,420	5
Ag. lands	1,344	1,129	2,341	1,965	6,779	24
Forest lands	2,278	3,658	3,970	6,374	16,280	58
Other lands	813	467	1,417	814	3,511	13
Totals	4,547	5,661	7,922	9,860	27,990	100
ORBES Region						
Public lands	630	1,013	1,095	1,767	4,505	2
Ag. lands	14,781	22,268	25,574	38,610	101,233	54
Forest lands	9,047	15,258	15,738	26,549	66,592	36
Other lands	2,352	3,070	4,085	5,292	14,799	8
Totals	26,810	41,609	46,492	72,218	187,129	100

TABLE 5-5 POTENTIAL LAND USE CONVERSION BY MAJOR CATEGORY FOR SCENARIO 1a
(Conventional Technology, Dispersed Siting, Very Strict Air).
(All units are acres).

Location and Major Land Use Category	Irreversible Commitment of Land Resources		Reversible Commitment of Land Resources		Total Land Use Conversion Through 2000	% of Total
	1985	2000	1985	2000		
Illinois						
Public lands	78	44	135	77	334	1
Ag. lands	4,380	4,816	7,459	8,237	24,892	81
Forest lands	471	743	800	1,278	3,292	11
Other lands	357	462	609	791	2,219	7
Totals	5,286	6,065	9,003	10,383	30,737	100
Indiana						
Public lands	240	160	416	281	1,097	3
Ag. lands	4,808	5,559	8,376	9,680	28,423	70
Forest lands	1,549	1,654	2,698	2,880	8,781	22
Other lands	354	494	616	870	2,334	5
Totals	6,951	7,867	12,106	13,711	40,635	100
Ohio						
Public lands	108	225	188	393	914	3
Ag. lands	1,133	5,801	1,973	10,108	19,015	60
Forest lands	1,276	1,926	2,222	3,393	8,817	28
Other lands	419	630	732	1,101	2,882	9
Totals	2,936	8,582	5,115	14,995	31,628	100
Kentucky						
Public lands	52	61	92	107	312	1
Ag. lands	2,733	4,676	4,758	8,148	20,315	56
Forest lands	2,353	2,625	4,098	4,569	13,645	37
Other lands	370	416	643	727	2,156	6
Totals	5,508	7,778	9,591	13,551	36,428	100
West Virginia						
Public lands	40	124	70	217	451	2
Ag. lands	383	1,104	667	1,923	4,077	21
Forest lands	1,120	4,059	1,950	7,070	14,199	72
Other lands	39	353	68	617	1,077	5
Totals	1,582	5,640	2,755	9,827	19,804	100
Pennsylvania						
Public lands	112	359	194	623	1,288	5
Ag. lands	1,344	1,431	2,341	2,492	7,608	27
Forest lands	2,278	3,368	3,970	5,869	15,485	55
Other lands	813	503	1,417	877	3,610	13
Totals	4,547	5,661	7,922	9,861	27,991	100
ORBES Region						
Public lands	630	973	1,095	1,698	4,396	2
Ag. lands	14,781	23,387	25,574	40,588	104,330	56
Forest lands	9,047	14,375	15,738	25,059	64,219	34
Other lands	2,352	2,858	4,085	4,983	14,278	8
Totals	26,810	41,593	46,492	72,328	187,223	100

TABLE 5-6 POTENTIAL LAND USE CONVERSION BY MAJOR CATEGORY FOR SCENARIO 1b (Conventional Technology, Very Strict Air, Concentrated Siting). (All units are acres).

Location and Major Land Use Category	Irreversible Commitment of Land Resources		Reversible Commitment of Land Resources		Total Land Use Conversion Through 2000	% of Total
	1985	2000	1985	2000		
Illinois						
Public lands	78	40	135	70	323	1
Ag. lands	4,380	5,128	7,459	8,832	25,799	81
Forest lands	471	639	800	1,096	3,006	9
Other lands	357	650	609	1,125	2,741	9
Totals	5,286	6,457	9,003	11,123	31,869	100
Indiana						
Public lands	240	177	416	309	1,142	3
Ag. lands	4,808	5,206	8,376	9,070	27,460	71
Forest lands	1,549	1,621	2,698	2,822	8,690	22
Other lands	354	249	616	434	1,653	4
Totals	6,951	7,253	12,106	12,635	38,945	100
Ohio						
Public lands	108	220	188	386	902	3
Ag. lands	1,133	4,892	1,973	8,521	16,519	52
Forest lands	1,276	2,909	2,222	5,100	11,507	37
Other lands	419	520	732	905	2,576	8
Totals	2,936	8,541	5,115	14,912	31,504	100
Kentucky						
Public lands	52	37	92	65	246	1
Ag. lands	2,733	3,900	4,758	6,797	18,188	53
Forest lands	2,353	2,448	4,098	4,263	13,162	39
Other lands	370	559	643	972	2,544	7
Totals	5,508	6,944	9,591	12,097	34,140	100
West Virginia						
Public lands	40	96	70	168	374	2
Ag. lands	383	879	667	1,530	3,459	17
Forest lands	1,120	4,481	1,950	7,806	15,357	78
Other lands	39	184	68	322	613	3
Totals	1,582	5,640	2,755	9,826	19,803	100
Pennsylvania						
Public lands	112	327	194	567	1,200	4
Ag. lands	1,344	1,511	2,341	2,633	7,829	28
Forest lands	2,278	3,678	3,970	6,409	16,335	59
Other lands	813	124	1,417	217	2,571	9
Totals	4,547	5,640	7,922	9,826	27,935	100
ORBES Region						
Public lands	630	897	1,095	1,565	4,187	2
Ag. lands	14,781	21,516	25,574	37,383	99,254	54
Forest lands	9,047	15,776	15,738	27,496	68,057	37
Other lands	2,352	2,286	4,085	3,975	12,698	7
Totals	26,810	40,475	46,492	70,419	184,196	100

TABLE 5-7 POTENTIAL LAND USE CONVERSION BY MAJOR CATEGORY FOR SCENARIO 1c (Conventional Technology, Ag. Lands Protection, Dispersed Siting, High Growth). (All units are acres).

Location and Major Land Use Category	Irreversible Commitment of Land Resources		Reversible Commitment of Land Resources		Total Land Use Conversion Through 2000	% of Total
	1985	2000	1985	2000		
Illinois						
Public lands	78	149	135	256	618	1
Ag. lands	4,380	3,740	7,459	6,374	21,953	77
Forest lands	471	1,035	800	1,764	4,070	14
Other lands	357	354	609	601	1,921	7
Totals	5,286	5,278	9,003	8,995	28,562	99
Indiana						
Public lands	240	148	416	259	1,063	3
Ag. lands	4,808	4,461	8,376	7,771	25,416	65
Forest lands	1,549	2,238	2,698	3,896	10,381	27
Other lands	354	405	616	707	2,082	5
Totals	6,951	7,252	12,106	12,633	38,942	100
Ohio						
Public lands	108	214	188	374	884	5
Ag. lands	1,133	1,440	1,973	2,511	7,057	41
Forest lands	1,276	1,486	2,222	2,588	7,572	44
Other lands	419	178	732	317	1,646	10
Totals	2,936	3,318	5,115	5,790	17,159	100
Kentucky						
Public lands	52	318	92	554	1,016	3
Ag. lands	2,733	3,131	4,758	5,454	16,076	49
Forest lands	2,353	2,749	4,098	4,787	13,987	43
Other lands	370	248	643	434	1,695	5
Totals	5,508	6,446	9,591	11,229	32,774	100
West Virginia						
Public lands	40	256	70	448	814	2
Ag. lands	383	1,972	667	3,431	6,453	20
Forest lands	1,120	7,847	1,950	13,669	24,586	74
Other lands	39	400	68	700	1,207	4
Totals	1,582	10,475	2,755	18,248	33,060	100
Pennsylvania						
Public lands	112	383	194	665	1,354	5
Ag. lands	1,344	1,176	2,341	2,050	6,911	25
Forest lands	2,278	3,481	3,970	6,066	15,795	56
Other lands	813	620	1,417	1,081	3,931	14
Totals	4,547	5,660	7,922	9,862	27,991	100
ORBES Region						
Public lands	630	1,468	1,095	2,556	5,749	3
Ag. lands	14,781	15,920	25,574	27,591	83,866	47
Forest lands	9,047	18,836	15,738	32,770	76,391	43
Other lands	2,352	2,205	4,085	3,840	12,482	7
Totals	26,810	38,429	46,492	66,757	178,488	100

TABLE 5-8 POTENTIAL LAND USE CONVERSION BY MAJOR CATEGORY FOR SCENARIO 1d (Conventional Technology, Ag. Lands Protection, Concentrated Siting). (All units are acres).

Location and Major Land Use Category	Irreversible Commitment of Land Resources		Reversible Commitment of Land Resources		Total Land Use Conversion Through 2000	% of Total
	1985	2000	1985	2000		
Illinois						
Public lands	78	186	135	318	717	3
Ag. lands	4,380	3,509	7,459	5,980	21,328	75
Forest lands	471	1,235	800	2,103	4,609	16
Other lands	357	351	609	595	1,912	6
Totals	5,286	5,281	9,003	8,996	28,566	100
Indiana						
Public lands	240	104	416	182	942	2
Ag. lands	4,808	4,690	8,376	8,172	26,046	67
Forest lands	1,549	2,178	2,698	3,792	10,217	26
Other lands	354	280	616	490	1,740	5
Totals	6,951	7,252	12,106	12,636	38,945	100
Ohio						
Public lands	108	443	188	774	1,513	6
Ag. lands	1,133	3,184	1,973	5,551	11,841	44
Forest lands	1,276	2,992	2,222	5,187	11,677	43
Other lands	419	326	732	569	2,046	7
Totals	2,936	6,945	5,115	12,081	27,077	100
Kentucky						
Public lands	52	524	92	912	1,580	5
Ag. lands	2,733	3,514	4,758	6,122	17,127	52
Forest lands	2,353	2,128	4,098	3,708	12,287	37
Other lands	370	280	643	490	1,783	6
Totals	5,508	6,446	9,591	11,232	32,777	100
West Virginia						
Public lands	40	80	70	140	330	1
Ag. lands	383	1,537	667	2,676	5,263	22
Forest lands	1,120	5,375	1,950	9,368	17,813	74
Other lands	39	260	68	455	822	3
Totals	1,582	7,252	2,755	12,639	24,228	100
Pennsylvania						
Public lands	112	304	194	532	1,142	4
Ag. lands	1,344	1,509	2,341	2,625	7,819	28
Forest lands	2,278	3,264	3,970	5,687	15,199	54
Other lands	813	563	1,417	983	3,776	14
Totals	4,547	5,640	7,922	9,827	27,936	100
ORBES Region						
Public lands	630	1,641	1,095	2,858	6,224	3
Ag. lands	14,781	17,943	25,574	31,126	89,424	50
Forest lands	9,047	17,172	15,738	29,845	71,802	40
Other lands	2,352	2,060	4,085	3,582	12,079	7
Totals	26,810	38,816	46,492	67,411	179,529	100

TABLE 5-9 POTENTIAL LAND USE CONVERSION BY MAJOR CATEGORY FOR SCENARIO 2 (Conventional Technology, Lax Controls). (All units are acres).

Location and Major Land Use Category	Irreversible Commitment of Land Resources 1985	Irreversible Commitment of Land Resources 2000	Reversible Commitment of Land Resources 1985	Reversible Commitment of Land Resources 2000	Total Land Use Conversion Through 2000	% of Total
Illinois						
Public lands	78	52	135	91	356	1
Ag. lands	4,380	4,147	7,459	7,060	23,046	81
Forest lands	471	706	800	1,202	3,179	11
Other lands	357	363	609	618	1,947	7
Totals	5,286	5,268	9,003	8,971	28,528	100
Indiana						
Public lands	240	128	416	225	1,009	3
Ag. lands	4,808	4,555	8,376	7,935	25,674	65
Forest lands	1,549	2,024	2,698	3,528	9,799	25
Other lands	354	761	616	1,327	3,058	7
Totals	6,951	7,468	12,106	13,015	39,540	100
Ohio						
Public lands	108	512	188	892	1,700	5
Ag. lands	1,133	3,652	1,973	6,364	13,122	42
Forest lands	1,276	3,893	2,222	6,784	14,175	45
Other lands	419	519	732	905	2,575	8
Totals	2,936	8,576	5,115	14,945	31,572	100
Kentucky						
Public lands	52	62	92	107	313	1
Ag. lands	2,733	4,717	4,758	8,217	20,425	56
Forest lands	2,353	2,210	4,098	3,847	12,508	34
Other lands	370	793	643	1,381	3,187	9
Totals	5,508	7,782	9,591	13,552	36,433	100
West Virginia						
Public lands	40	88	70	154	352	2
Ag. lands	383	1,294	667	2,254	4,598	23
Forest lands	1,120	3,676	1,950	6,402	13,148	66
Other lands	39	584	68	1,017	1,708	9
Totals	1,582	5,642	2,755	9,827	19,806	100
Pennsylvania						
Public lands	112	296	194	518	1,120	4
Ag. lands	1,344	1,689	2,341	2,941	8,315	30
Forest lands	2,278	2,953	3,970	5,146	14,347	51
Other lands	813	721	1,417	1,257	4,208	15
Totals	4,547	5,659	7,922	9,862	27,990	100
ORBES Region						
Public lands	630	1,129	1,095	1,973	4,827	2
Ag. lands	14,781	20,324	25,574	35,241	95,920	52
Forest lands	9,047	15,519	15,738	27,007	67,311	37
Other lands	2,352	3,422	4,085	5,950	15,809	9
Totals	26,810	40,395	46,492	70,172	183,869	100

TABLE 5-10 POTENTIAL LAND USE CONVERSION BY MAJOR CATEGORY FOR SCENARIO 2a (Conventional Technology, Lax Controls, Coal Export). (All units are acres).

Location and Major Land Use Category	Irreversible Commitment of Land Resources 1985	Irreversible Commitment of Land Resources 2000	Reversible Commitment of Land Resources 1985	Reversible Commitment of Land Resources 2000	Total Land Use Conversion Through 2000	% of Total
Illinois						
Public lands	78	52	135	91	356	1
Ag. lands	4,380	4,147	7,459	7,060	23,046	81
Forest lands	471	706	800	1,202	3,179	11
Other lands	357	363	609	618	1,947	7
Totals	5,286	5,268	9,003	8,971	28,528	100
Indiana						
Public lands	240	128	416	225	1,009	3
Ag. lands	4,808	4,555	8,376	7,935	25,674	65
Forest lands	1,549	2,024	2,698	3,528	9,799	25
Other lands	354	761	616	1,327	3,058	7
Totals	6,951	7,468	12,106	13,015	39,540	100
Ohio						
Public lands	108	841	188	1,467	2,604	6
Ag. lands	1,133	5,743	1,973	10,008	18,857	41
Forest lands	1,276	6,257	2,222	10,904	20,659	45
Other lands	419	969	732	1,690	3,810	8
Totals	2,936	13,810	5,115	24,069	45,930	100
Kentucky						
Public lands	52	62	92	107	313	1
Ag. lands	2,733	4,717	4,758	8,217	20,425	56
Forest lands	2,353	2,210	4,098	3,847	12,508	34
Other lands	370	793	643	1,381	3,187	9
Totals	5,508	7,782	9,591	13,552	36,433	100
West Virginia						
Public lands	40	148	70	259	517	2
Ag. lands	383	2,225	667	3,875	7,150	22
Forest lands	1,120	6,755	1,950	11,767	21,592	68
Other lands	39	946	68	1,649	2,702	8
Totals	1,582	10,074	2,755	17,550	31,961	100
Pennsylvania						
Public lands	112	408	194	714	1,428	4
Ag. lands	1,344	2,105	2,341	3,663	9,453	28
Forest lands	2,278	4,344	3,970	7,567	18,159	54
Other lands	813	818	1,417	1,425	4,473	13
Totals	4,547	7,675	7,922	13,369	33,513	99
ORBES Region						
Public lands	630	1,639	1,095	2,863	6,227	3
Ag. lands	14,781	23,492	25,574	40,758	104,605	48
Forest lands	9,047	22,296	15,738	38,815	85,896	40
Other lands	2,352	4,650	4,085	8,090	19,177	9
Totals	26,810	52,077	46,492	90,526	215,905	100

TABLE 5-11 POTENTIAL LAND USE CONVERSION BY MAJOR CATEGORY FOR SCENARIO 2b
(Conventional Technology, Lax Controls, Nuclear Export)
(All units are acres)

Location and Major Land Use Category	Irreversible Commitment of Land Resources 1985	Irreversible Commitment of Land Resources 2000	Reversible Commitment of Land Resources 1985	Reversible Commitment of Land Resources 2000	Total Land Use Conversion Through 2000	% of Total
Illinois						
Public lands	78	58	135	102	373	1
Ag. lands	4,380	4,693	7,459	8,010	24,542	81
Forest lands	471	731	800	1,245	3,247	11
Other lands	357	406	609	694	2,066	7
Totals	5,286	5,888	9,003	10,051	30,228	100
Indiana						
Public lands	240	190	416	333	1,179	3
Ag. lands	4,808	4,908	8,376	8,551	26,643	65
Forest lands	1,549	2,191	2,698	3,820	10,258	25
Other lands	354	798	616	1,392	3,160	7
Totals	6,951	8,087	12,106	14,096	41,240	100
Ohio						
Public lands	108	773	188	1,345	2,414	5
Ag. lands	1,133	6,529	1,973	11,375	21,010	43
Forest lands	1,276	6,596	2,222	11,494	21,588	44
Other lands	419	917	732	1,598	3,666	8
Totals	2,936	14,815	5,115	25,812	48,678	100
Kentucky						
Public lands	52	62	92	107	313	1
Ag. lands	2,733	4,717	4,758	8,217	20,425	56
Forest lands	2,353	2,210	4,098	3,847	12,508	34
Other lands	370	793	643	1,381	3,187	9
Totals	5,508	7,782	9,591	13,552	36,433	100
West Virginia						
Public lands	40	88	70	154	352	2
Ag. lands	383	1,294	667	2,254	4,598	23
Forest lands	1,120	3,676	1,950	6,402	13,148	66
Other lands	39	584	68	1,017	1,708	9
Totals	1,582	5,642	2,755	9,827	19,806	100
Pennsylvania						
Public lands	112	520	194	906	1,732	4
Ag. lands	1,344	3,201	2,341	5,577	12,463	30
Forest lands	2,278	5,383	3,970	9,380	21,011	51
Other lands	813	1,515	1,417	2,639	6,384	15
Totals	4,547	10,619	7,922	18,507	41,590	100
ORBES Region						
Public lands	630	1,691	1,095	2,947	6,363	3
Ag. lands	14,781	25,342	25,574	43,984	109,681	50
Forest lands	9,047	20,787	15,738	36,188	81,760	38
Other lands	2,352	5,013	4,085	8,721	20,171	9
Totals	26,810	52,833	46,492	91,840	217,975	100

TABLE 5-12. POTENTIAL LAND USE CONVERSION BY MAJOR CATEGORY FOR SCENARIO 2c (Conventional Technology, Nuclear, Base Case, High Growth). (All units are acres)

Location and Major Land Use Category	Irreversible Commitment of Land Resources		Reversible Commitment of Land Resources		Total Land Use Conversion Through 2000	% of Total
	1985	2000	1985	2000		
Illinois						
Public lands	78	160	135	284	657	1
Ag. lands	4,380	11,495	7,459	20,024	43,358	82
Forest lands	471	1,406	800	2,447	5,124	10
Other lands	357	1,120	609	1,945	4,031	7
Totals	5,286	14,181	9,003	24,700	53,170	100
Indiana						
Public lands	240	52	416	103	811	2
Ag. lands	4,808	5,126	8,376	8,927	27,237	69
Forest lands	1,549	1,732	2,698	3,018	8,997	23
Other lands	354	460	616	805	2,235	6
Totals	6,951	7,370	12,106	12,853	39,280	100
Ohio						
Public lands	108	180	188	315	791	4
Ag. lands	1,133	2,714	1,973	4,726	10,546	47
Forest lands	1,276	1,847	2,222	3,216	8,561	38
Other lands	419	442	732	771	2,364	11
Totals	2,936	5,183	5,115	9,028	22,262	100
Kentucky						
Public lands	52	9	92	16	169	1
Ag. lands	2,733	1,892	4,758	3,296	12,679	53
Forest lands	2,353	884	4,098	1,537	8,872	40
Other lands	370	160	643	290	1,463	6
Totals	5,508	2,945	9,591	5,139	23,183	100
West Virginia						
Public lands	40	207	70	361	678	4
Ag. lands	383	1,648	667	2,871	5,569	32
Forest lands	1,120	2,403	1,950	4,186	9,659	56
Other lands	39	453	68	789	1,349	8
Totals	1,582	4,711	2,755	8,207	17,255	100
Pennsylvania						
Public lands	112	28	194	49	383	2
Ag. lands	1,344	456	2,341	794	4,935	26
Forest lands	2,278	1,728	3,970	3,012	10,988	57
Other lands	813	205	1,417	358	2,793	15
Totals	4,547	2,417	7,922	4,213	19,099	100
ORBES Region						
Public lands	630	636	1,095	1,128	3,489	2
Ag. lands	14,781	23,331	25,574	40,638	104,324	59
Forest lands	9,047	10,000	15,738	17,416	52,201	31
Other lands	2,352	2,840	4,085	4,958	14,235	8
Totals	26,810	36,807	46,492	64,140	174,249	100

TABLE 5-13 POTENTIAL LAND USE CONVERSION BY MAJOR CATEGORY FOR SCENARIO 3. (Alternative Technology, Base Case, Lax Controls, High Growth). (All units are acres).

Location and Major Land Use Category	Irreversible Commitment of Land Resources		Reversible Commitment of Land Resources		Total Land Use Conversion Through 2000	% of Total
	1985	2000	1985	2000		
Illinois						
Public lands	78	44	135	77	334	1
Ag. lands	4,380	3,639	7,459	6,211	21,689	82
Forest lands	471	440	800	752	2,463	9
Other lands	357	325	609	555	1,846	7
Totals	5,286	4,448	9,003	7,595	26,332	99
Indiana						
Public lands	240	80	416	141	877	2
Ag. lands	4,808	3,840	8,376	6,692	23,716	68
Forest lands	1,549	1,351	2,698	2,356	7,954	23
Other lands	354	584	616	1,018	2,572	7
Totals	6,951	5,855	12,106	10,207	35,119	100
Ohio						
Public lands	108	358	188	626	1,280	5
Ag. lands	1,133	2,697	1,973	4,701	10,504	42
Forest lands	1,276	2,681	2,222	4,673	10,852	44
Other lands	419	402	732	702	2,255	9
Totals	2,936	6,138	5,115	10,702	24,891	100
Kentucky						
Public lands	52	29	92	51	224	1
Ag. lands	2,733	3,830	4,758	6,673	17,994	58
Forest lands	2,353	1,553	4,098	2,702	10,706	35
Other lands	370	353	643	616	1,982	6
Totals	5,508	5,765	9,591	10,042	30,906	100
West Virginia						
Public lands	40	68	70	189	367	2
Ag. lands	382	762	667	1,994	3,805	21
Forest lands	1,120	2,845	1,950	6,906	12,821	71
Other lands	39	354	68	685	1,146	6
Totals	1,581	4,029	2,755	9,774	18,139	100
Pennsylvania						
Public lands	116	184	203	322	825	4
Ag. lands	1,465	1,085	2,552	1,888	6,990	30
Forest lands	2,481	2,115	4,324	3,685	12,605	54
Other lands	876	242	1,526	421	3,065	13
Totals	4,938	3,626	8,605	6,316	23,485	101
ORBES Region						
Public lands	634	763	1,104	1,406	3,907	3
Ag. lands	14,901	15,853	25,785	28,159	84,698	53
Forest lands	9,250	10,985	16,092	21,074	57,401	36
Other lands	2,415	2,260	4,194	3,997	12,866	8
Totals	27,200	29,861	47,175	54,636	158,872	100

TABLE 5-14 POTENTIAL LAND USE CONVERSION BY MAJOR CATEGORY FOR SCENARIO 4
(Conventional Technology, Lax Controls, Natural Gas).
(All units in acres).

Location and Major Land Use Category	Irreversible Commitment of Land Resources		Reversible Commitment of Land Resources		Total Land Use Conversion Through 2000	% of Total
	1985	2000	1985	2000		
Illinois						
Public lands	60	50	104	87	301	1
Ag. lands	2,863	3,424	4,857	5,849	16,993	82
Forest lands	305	489	516	834	2,144	10
Other lands	240	276	408	471	1,395	7
Totals	3,468	4,239	5,885	7,241	20,833	100
Indiana						
Public lands	153	139	265	243	800	3
Ag. lands	3,016	4,194	5,253	7,308	19,771	69
Forest lands	798	1,547	1,389	2,696	6,430	23
Other lands	207	336	360	587	1,490	5
Totals	4,174	6,216	7,267	10,834	28,491	100
Ohio						
Public lands	61	208	110	359	738	4
Ag. lands	632	1,992	1,100	3,471	7,195	43
Forest lands	794	1,808	1,383	3,148	7,133	42
Other lands	323	341	565	595	1,824	11
Totals	1,810	4,349	3,158	7,573	16,890	100
Kentucky						
Public lands	13	43	23	76	155	1
Ag. lands	1,457	2,614	2,533	4,557	11,161	54
Forest lands	697	2,217	1,214	3,860	7,988	39
Other lands	252	231	434	405	1,322	6
Totals	2,419	5,105	4,204	8,898	20,626	100
West Virginia						
Public lands	40	76	70	133	319	2
Ag. lands	383	677	667	1,180	2,907	20
Forest lands	1,120	2,620	1,950	4,563	10,253	72
Other lands	39	253	68	442	802	6
Totals	1,582	3,626	2,755	6,318	14,281	100
Pennsylvania						
Public lands	93	71	162	123	449	3
Ag. lands	948	1,078	1,651	1,877	5,554	33
Forest lands	1,590	1,417	2,772	2,469	8,248	49
Other lands	620	342	1,081	596	2,639	16
Totals	3,251	2,908	5,666	5,065	16,890	101
ORBES Region						
Public lands	420	587	734	1,021	2,762	2
Ag. lands	9,299	13,979	16,061	24,242	63,581	54
Forest lands	5,304	10,098	9,224	17,570	42,196	36
Other lands	1,681	1,779	2,916	3,096	9,472	8
Totals	16,704	26,443	28,935	45,929	118,011	101

TABLE 5-15 POTENTIAL LAND USE CONVERSION BY MAJOR CATEGORY FOR SCENARIO 5 (Conventional Technology, Lax Controls, Low Growth). (All units in acres).

Location and Major Land Use Category	Irreversible Commitment of Land Resources 1985	Irreversible Commitment of Land Resources 2000	Reversible Commitment of Land Resources 1985	Reversible Commitment of Land Resources 2000	Total Land Use Conversion Through 2000	% of Total
Illinois						
Public lands	78	44	135	77	334	1
Ag. lands	4,380	3,228	7,459	5,496	20,563	82
Forest lands	471	510	800	869	2,650	11
Other lands	357	265	609	451	1,682	7
Totals	5,286	4,047	9,003	6,893	25,229	100
Indiana						
Public lands	240	104	416	183	943	3
Ag. lands	4,808	4,042	8,376	7,043	24,269	67
Forest lands	1,549	1,512	2,698	2,636	8,395	23
Other lands	354	600	616	1,046	2,616	7
Totals	6,951	6,258	12,106	10,908	36,223	100
Ohio						
Public lands	108	419	188	731	1,446	5
Ag. lands	1,133	3,196	1,973	5,571	11,873	42
Forest lands	1,276	3,268	2,222	5,696	12,462	44
Other lands	419	462	732	807	2,420	9
Totals	2,936	7,345	5,115	12,805	28,201	100
Kentucky						
Public lands	52	46	92	79	269	1
Ag. lands	2,733	4,225	4,758	7,361	19,077	58
Forest lands	2,353	1,887	4,098	3,285	11,623	35
Other lands	370	414	643	721	2,148	6
Totals	5,508	6,572	9,591	11,446	33,117	100
West Virginia						
Public lands	40	84	70	147	341	2
Ag. lands	383	1,012	667	1,762	3,824	22
Forest lands	1,120	3,301	1,950	5,749	12,120	69
Other lands	39	438	68	764	1,309	7
Totals	1,582	4,835	2,755	8,422	17,594	100
Pennsylvania						
Public lands	112	200	194	350	856	3
Ag. lands	1,344	1,415	2,341	2,464	7,564	31
Forest lands	2,278	2,409	3,970	4,198	12,855	52
Other lands	813	407	1,417	709	3,346	14
Totals	4,547	4,431	7,922	7,721	24,621	100
ORBES Region						
Public lands	630	897	1,095	1,567	4,189	3
Ag. lands	14,781	17,118	25,574	29,697	87,170	53
Forest lands	9,047	14,400	15,738	22,433	60,105	36
Other lands	2,352	2,586	4,085	4,498	13,521	8
Totals	26,810	33,488	46,492	58,195	164,985	100

TABLE 5-16 POTENTIAL LAND USE CONVERSION BY MAJOR CATEGORY FOR SCENARIO 5 a (Conventional Technology, Coal, Base Case, Very High Growth). (All units are acres).

Location and Major Land Use Category	Irreversible Commitment of Land Resources		Reversible Commitment of Land Resources		Total Land Use Conversion Through 2000	% of Total
	1985	2000	1985	2000		
Illinois						
Public lands	78	60	135	140	413	1
Ag. lands	4,380	4,779	7,459	8,659	25,277	80
Forest lands	471	695	800	1,348	3,314	11
Other lands	357	531	609	939	2,436	8
Totals	5,286	6,065	9,003	11,086	31,440	100
Indiana						
Public lands	240	228	416	400	1,284	3
Ag. lands	4,808	6,163	8,376	10,736	30,083	64
Forest lands	1,549	2,951	2,698	5,143	12,341	26
Other lands	354	945	616	1,650	3,565	8
Totals	6,951	10,287	12,106	17,929	47,273	101
Ohio						
Public lands	108	572	188	997	1,865	5
Ag. lands	1,133	4,941	1,973	8,611	16,658	44
Forest lands	1,276	4,723	2,222	8,231	16,452	43
Other lands	419	757	732	1,319	3,227	8
Totals	2,936	10,993	5,115	19,158	38,202	100
Kentucky						
Public lands	52	70	92	121	335	1
Ag. lands	2,733	6,095	4,758	10,618	24,204	56
Forest lands	2,353	3,097	4,098	5,391	14,939	35
Other lands	370	937	643	1,633	3,583	8
Totals	5,508	10,199	9,591	17,763	43,061	100
West Virginia						
Public lands	40	104	70	182	396	2
Ag. lands	383	1,766	667	3,075	5,891	23
Forest lands	1,120	4,768	1,950	8,305	16,143	64
Other lands	39	1,020	68	1,775	2,902	11
Totals	1,582	7,658	2,755	13,337	25,332	100
Pennsylvania						
Public lands	112	408	194	714	1,428	4
Ag. lands	1,344	2,040	2,341	3,551	9,276	29
Forest lands	2,278	3,969	3,970	6,914	17,131	53
Other lands	813	853	1,417	1,488	4,571	14
Totals	4,547	7,270	7,922	12,667	32,406	100
ORBES Region						
Public lands	630	1,442	1,095	2,554	5,721	3
Ag. lands	14,781	25,784	25,574	45,250	111,389	51
Forest lands	9,047	20,203	15,738	35,332	80,320	37
Other lands	2,352	5,043	4,085	8,804	20,284	9
Totals	26,810	52,472	46,492	91,940	217,714	100

TABLE 5-17 POTENTIAL LAND USE CONVERSION BY MAJOR CATEGORY FOR SCENARIO 6 (Conventional Technology, Coal, Base Case, Very Low Growth). (All units are acres).

Location and Major Land Use Category	Irreversible Commitment of Land Resources 1985	Irreversible Commitment of Land Resources 2000	Reversible Commitment of Land Resources 1985	Reversible Commitment of Land Resources 2000	Total Land Use Conversion Through 2000	% of Total
Illinois						
Public lands	75	31	129	55	290	2
Ag. lands	4,080	1,532	6,936	2,646	15,194	81
Forest lands	457	246	776	426	1,905	10
Other lands	333	133	567	230	1,263	7
Totals	4,945	1,942	8,408	3,357	18,652	100
Indiana						
Public lands	153	99	265	173	690	3
Ag. lands	3,017	3,408	5,253	5,938	17,616	70
Forest lands	798	1,252	1,389	2,182	5,621	22
Other lands	207	248	360	433	1,248	5
Totals	4,175	5,007	7,267	8,726	25,175	100
Ohio						
Public lands	66	103	117	178	464	3
Ag. lands	888	1,782	1,546	3,106	7,322	46
Forest lands	950	1,335	1,654	2,327	6,266	39
Other lands	409	320	715	558	2,002	12
Totals	2,313	3,540	4,032	6,169	16,054	100
Kentucky						
Public lands	17	44	28	77	166	1
Ag. lands	1,402	2,624	2,443	4,574	11,043	53
Forest lands	626	2,340	1,092	4,077	8,135	39
Other lands	369	219	642	384	1,614	8
Totals	2,414	5,227	4,205	9,112	20,958	101
West Virginia						
Public lands	40	24	70	42	176	2
Ag. lands	383	307	667	534	1,891	22
Forest lands	1,120	1,225	1,950	2,134	6,429	73
Other lands	39	56	68	98	261	3
Totals	1,582	1,612	2,755	2,808	8,757	100
Pennsylvania						
Public lands	89	43	162	67	361	2
Ag. lands	948	799	1,651	1,392	4,790	33
Forest lands	1,590	990	2,772	1,725	7,077	48
Other lands	620	273	1,081	476	2,450	17
Totals	3,247	2,105	5,666	3,660	14,678	100
ORBES Region						
Public lands	440	344	771	592	2,147	2
Ag. lands	10,718	10,452	18,496	18,190	57,856	55
Forest lands	5,541	7,388	9,633	12,871	35,433	34
Other lands	1,977	1,249	3,433	2,179	8,838	8
Totals	18,676	19,433	32,333	33,832	104,274	99

TABLE 5-18 POTENTIAL LAND USE CONVERSION BY MAJOR CATEGORY FOR SCENARIO 7 (Conventional Technology, Base Case, High Economic Growth, 45 Year Plant Life) (All units are acres)

Location and Major Land Use Category	Irreversible Commitment of Land Resources		Reversible Commitment of Land Resources		Total Land Use Conversion Through 2000	% of Total
	1985	2000	1985	2000		
Illinois						
Public lands	78	60	135	105	378	1
Ag. lands	4,380	5,041	7,459	8,630	25,510	80
Forest lands	471	784	800	1,347	3,402	11
Other lands	357	583	609	1,002	2,551	8
Totals	5,286	6,468	9,003	11,084	31,841	100
Indiana						
Public lands	240	232	416	407	1,295	3
Ag. lands	4,808	6,356	8,376	11,073	30,613	63
Forest lands	1,549	3,112	2,698	5,424	12,783	26
Other lands	354	989	616	1,727	3,686	8
Totals	6,951	10,689	12,106	18,631	48,377	100
Ohio						
Public lands	108	736	188	1,284	2,316	5
Ag. lands	1,133	5,996	1,973	10,450	19,552	44
Forest lands	1,276	5,381	2,222	9,374	18,253	41
Other lands	419	1,317	732	2,295	4,763	11
Totals	2,936	13,430	5,115	23,403	44,884	100
Kentucky						
Public lands	52	110	92	191	445	1
Ag. lands	2,733	7,659	4,758	13,340	28,490	57
Forest lands	2,353	3,847	4,098	6,695	16,993	34
Other lands	370	1,001	643	1,745	3,759	8
Totals	5,508	12,617	9,591	21,971	49,687	100
West Virginia						
Public lands	40	184	70	322	616	2
Ag. lands	383	1,983	667	3,454	6,487	20
Forest lands	1,120	6,734	1,950	11,731	21,535	67
Other lands	39	1,173	68	2,041	3,321	10
Totals	1,582	10,074	2,755	17,548	31,959	99
Pennsylvania						
Public lands	112	348	194	609	1,263	4
Ag. lands	1,344	1,854	2,341	3,228	8,767	29
Forest lands	2,278	3,461	3,970	6,030	15,739	52
Other lands	813	801	1,417	1,397	4,428	15
Totals	4,547	6,464	7,922	11,264	30,197	100
ORBES Region						
Public lands	630	1,670	1,095	2,918	6,313	3
Ag. lands	14,781	28,889	25,575	50,175	119,419	50
Forest lands	9,047	23,319	15,738	40,601	88,705	37
Other lands	2,352	5,864	4,085	10,207	22,508	10
Totals	26,810	59,742	46,492	103,901	236,945	100

TABLE 5-19. SUMMARY OF MAXIMUM ABSOLUTE VALUES (ACRES) AND RELATIVE VALUES (PERCENTAGE) OF LAND USE CONVERSION FOR EACH MAJOR CATEGORY BY SCENARIO

	Maximum Absolute Values (Acres)					Maximum Relative Values (%)				Maximum Relative Conversion-State (%)[a]	Maximum Conversion Category (Region)
Scenario	Public	Ag.	Forest	Other	Total	Public	Ag.	Forest	Other		
1	1,420 PA	26,534 IN	16,280 PA	3,511 PA	40,643 IN	5 PA	80 IL	74 WV	13 PA	.18 IN	Agriculture
1A	1,288 PA	28,423 IN	15,485 PA	3,610 PA	40,635 IN	5 PA	81 IL	72 WV	13 PA	.18 IN	Agriculture
1B	1,200 PA	27,460 IN	16,355 PA	2,741 IL	38,945 IN	4 PA	81 IL	78 WV	9 IL,PA	.17 IN	Agriculture
1C	1,354 PA	25,416 IN	15,795 PA	3,931 PA	39,942 IN	5 OH,PA	77 IL	74 WV	14 PA	.21 WV	Agriculture
1D	1,580 KY	26,046 IN	17,813 WV	3,776 PA	38,945 IN	6 OH	75 IL	74 WV	14 PA	.17 IN	Agriculture
2	1,700 OH	25,674 IN	14,347 PA	4,208 PA	39,540 IN	5 OH	81 IL	66 WV	15 PA	.17 IN	Agriculture
2A	2,604 OH	25,674 IN	21,592 WV	4,473 PA	45,930 OH	6 OH	81 IL	68 WV	13 PA	.21 WV	Agriculture
2B	2,414 OH	26,643 IN	21,588 OH	6,384 PA	48,678 OH	5 OH	81 IL	66 WV	15 PA	.19 OH	Agriculture
2C	811 IN	43,358 IL	10,988 PA	4,031 IL	53,170 IL	4 OH,WV	82 IL	57 PA	15 PA	.17 IN	Agriculture
3	1,280 OH	23,716 IN	12,821 WV	3,065 PA	35,119 IN	5 OH	82 IL	71 WV	13 PA	.15 IN	Agriculture
4	800 IN	19,771 IN	10,253 WV	2,639 PA	28,491 IN	4 OH	82 IL	72 WV	16 PA	.12 IN	Agriculture

Continued

TABLE 5-19. Continued

	Maximum Absolute Values (Acres)					Maximum Relative Values (%)				Maximum Relative Conversion-State (%)[a]	Maximum Conversion Category (Region)
Scenario	Public	Ag.	Forest	Other	Total	Public	Ag.	Forest	Other		
5	1,446 OH	24,269 IN	12,855 PA	3,346 PA	36,223 IN	5 OH	82 IL	69 WV	14 PA	.16 IN	Agriculture
5A	1,865 OH	30,083 IN	17,131 PA	4,571 PA	47,273 IN	5 OH	80 IL	64 WV	14 PA	.20 IN	Agriculture
6	690 IN	17,616 IN	8,135 KY	2,450 PA	25,175 IN	3 IN,OH	81 IL	73 WV	17 PA	.11 IN	Agriculture
7	2,316 OH	30,613 IN	21,535 WV	4,763 OH	49,687 KY	5 OH	80 IL	67 WV	15 PA	.21 IN	Agriculture

[a] Maximum total conversion relative to the total land area of a state.

Illinois :Total Land Use Conversion By Electrical Generating Facilities, 1975—2000

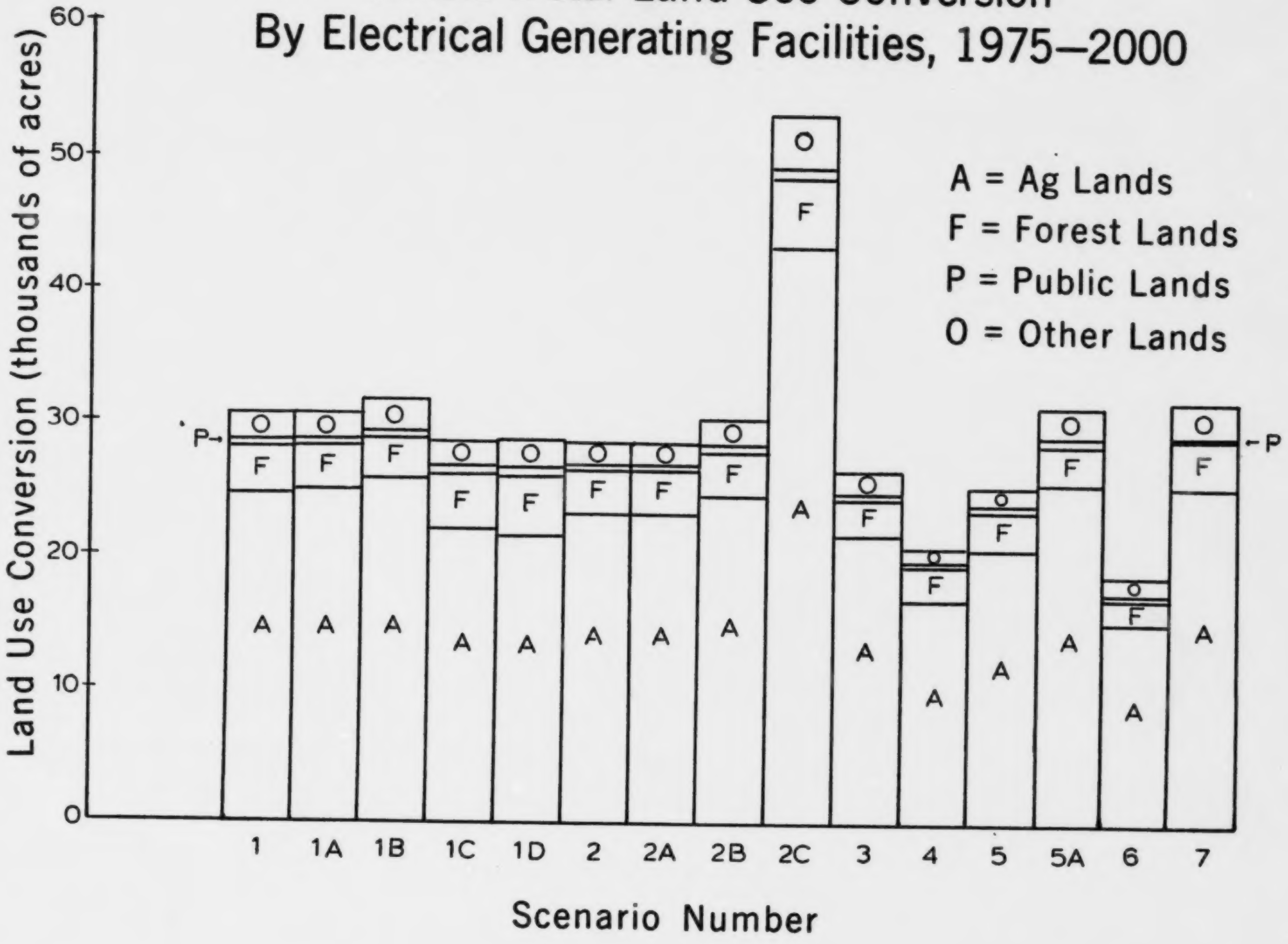


Figure 5-2

Indiana : Total Land Use Conversion
By Electrical Generating Facilities, 1975—2000

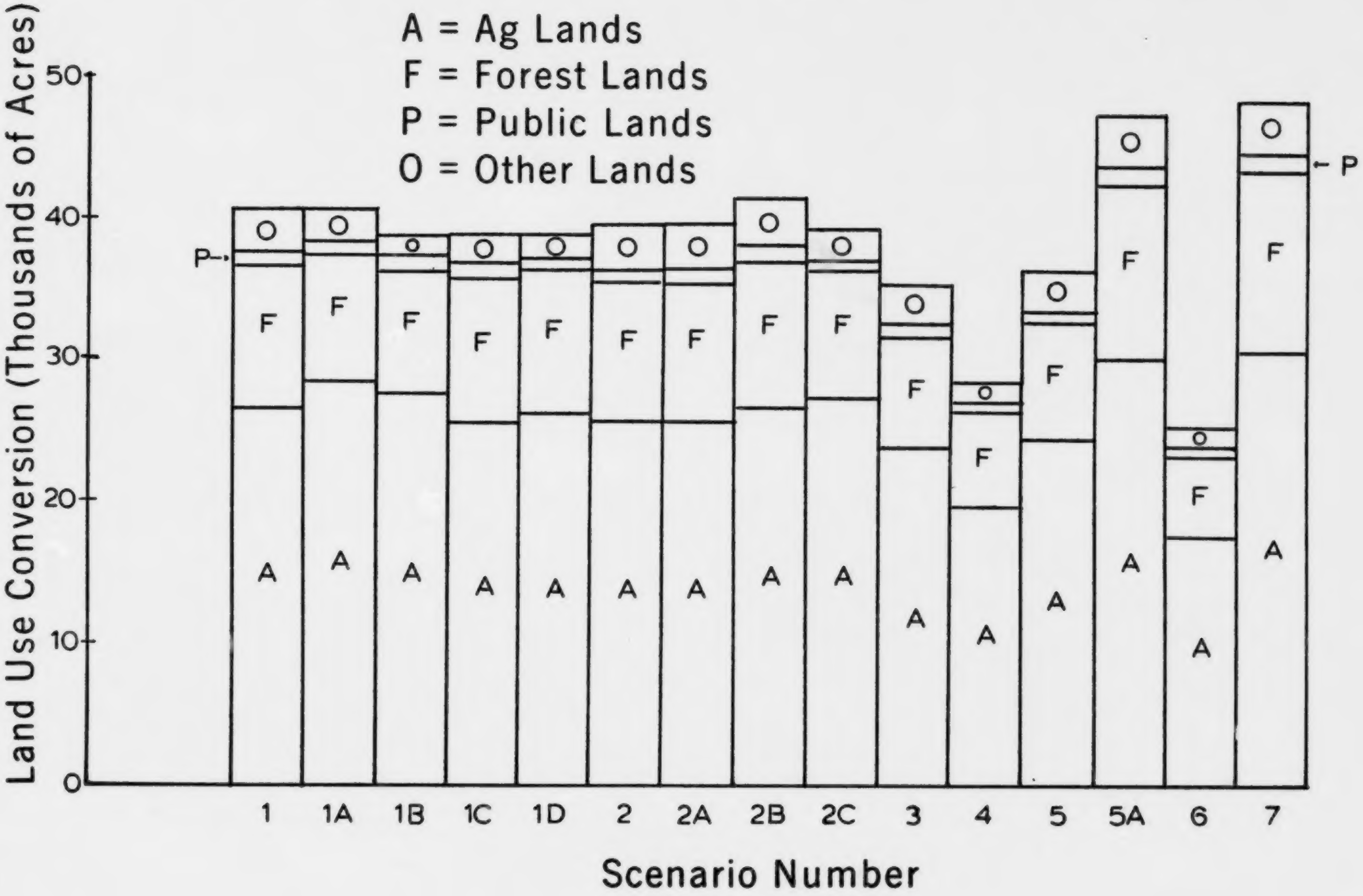


Figure 5-3

Kentucky : Total Land Use Conversion By Electrical Generating Facilities, 1975–2000

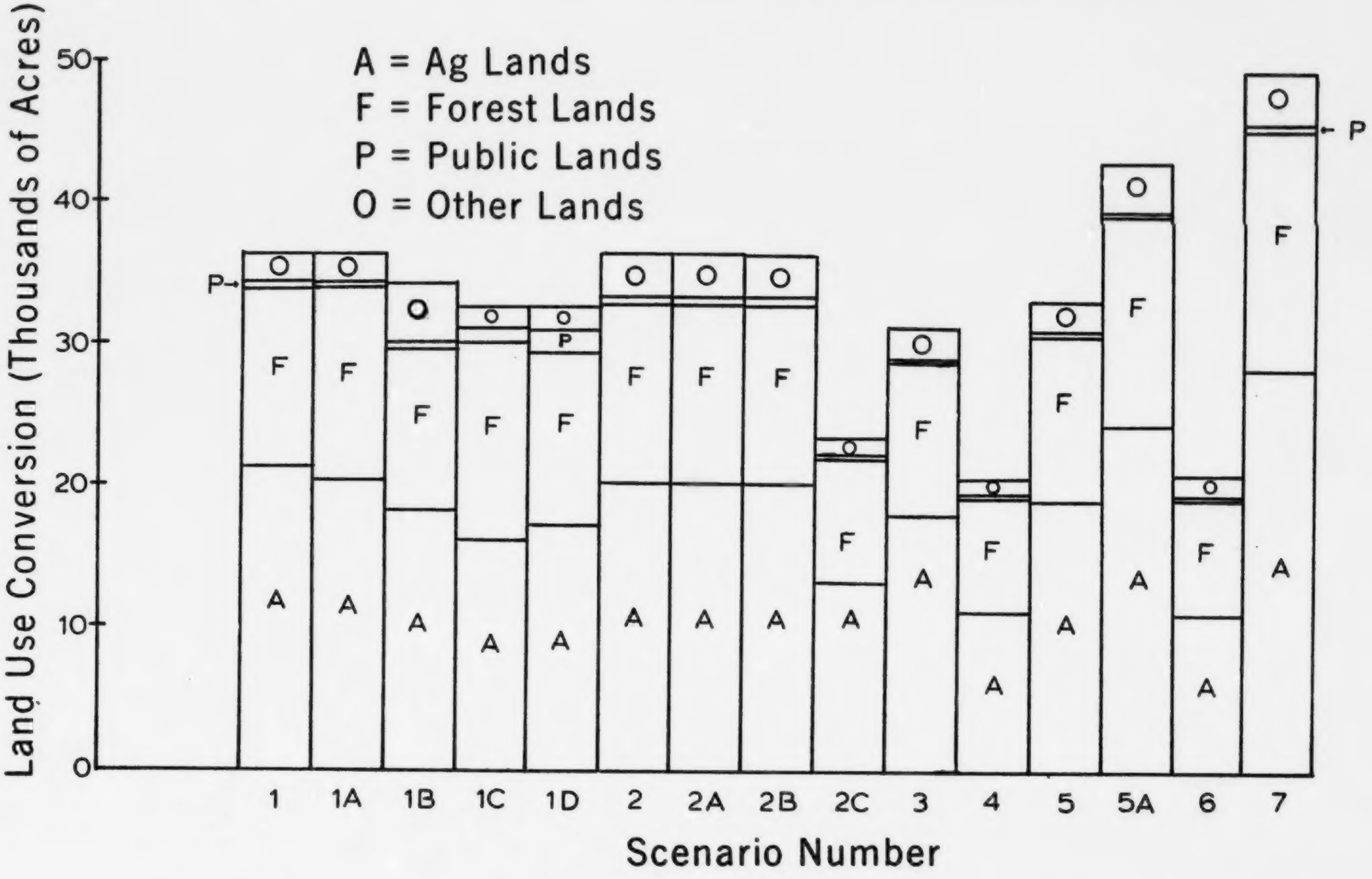


Figure 5-4

Ohio : Total Land Use Conversion
By Electrical Generating Facilities, 1975—2000

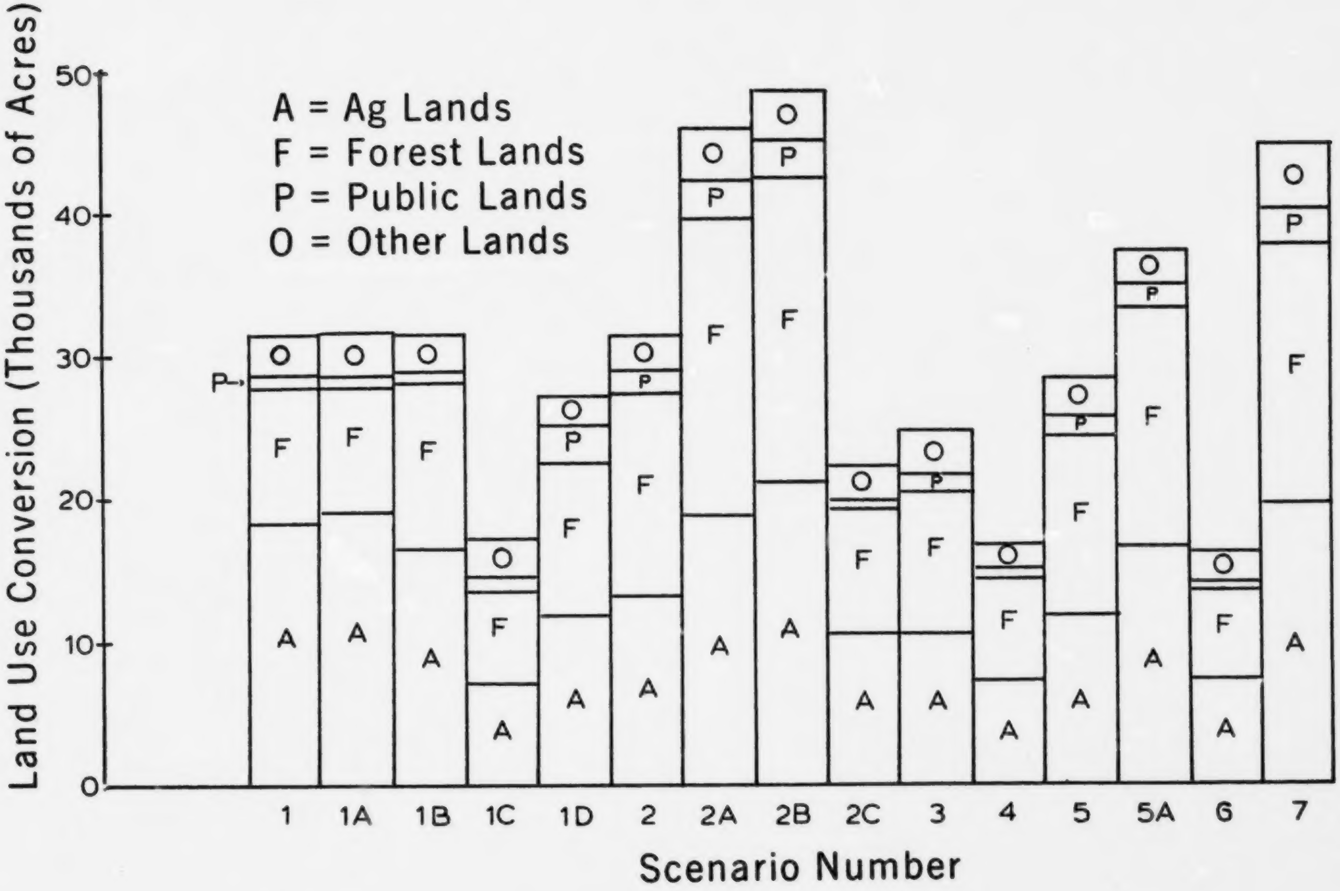


Figure 5-5

Pennsylvania : Total Land Use Conversion
By Electrical Generating Facilities, 1975–2000

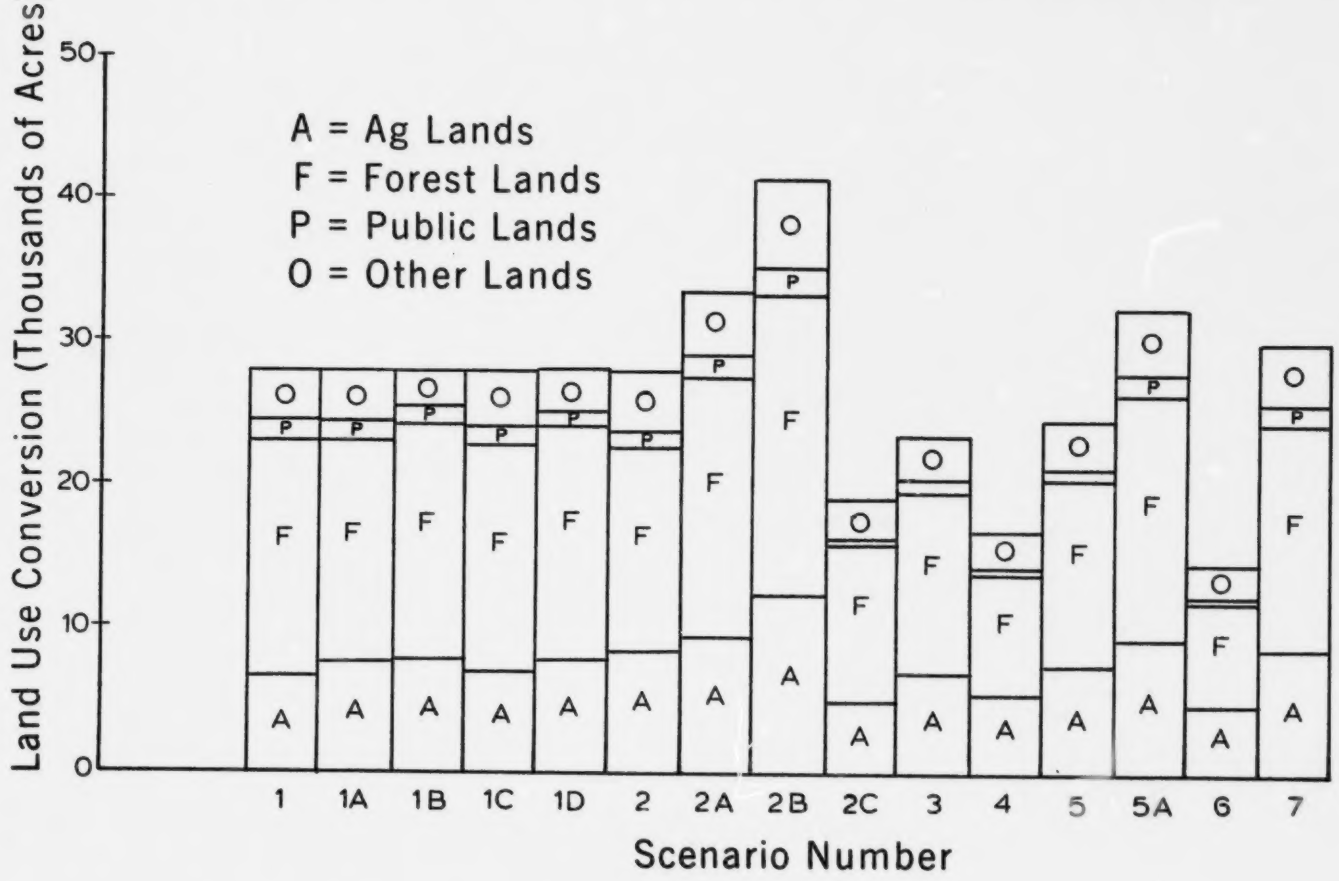


Figure 5-6

West Virginia : Total Land Use Conversion By Electrical Generating Facilities, 1975–2000

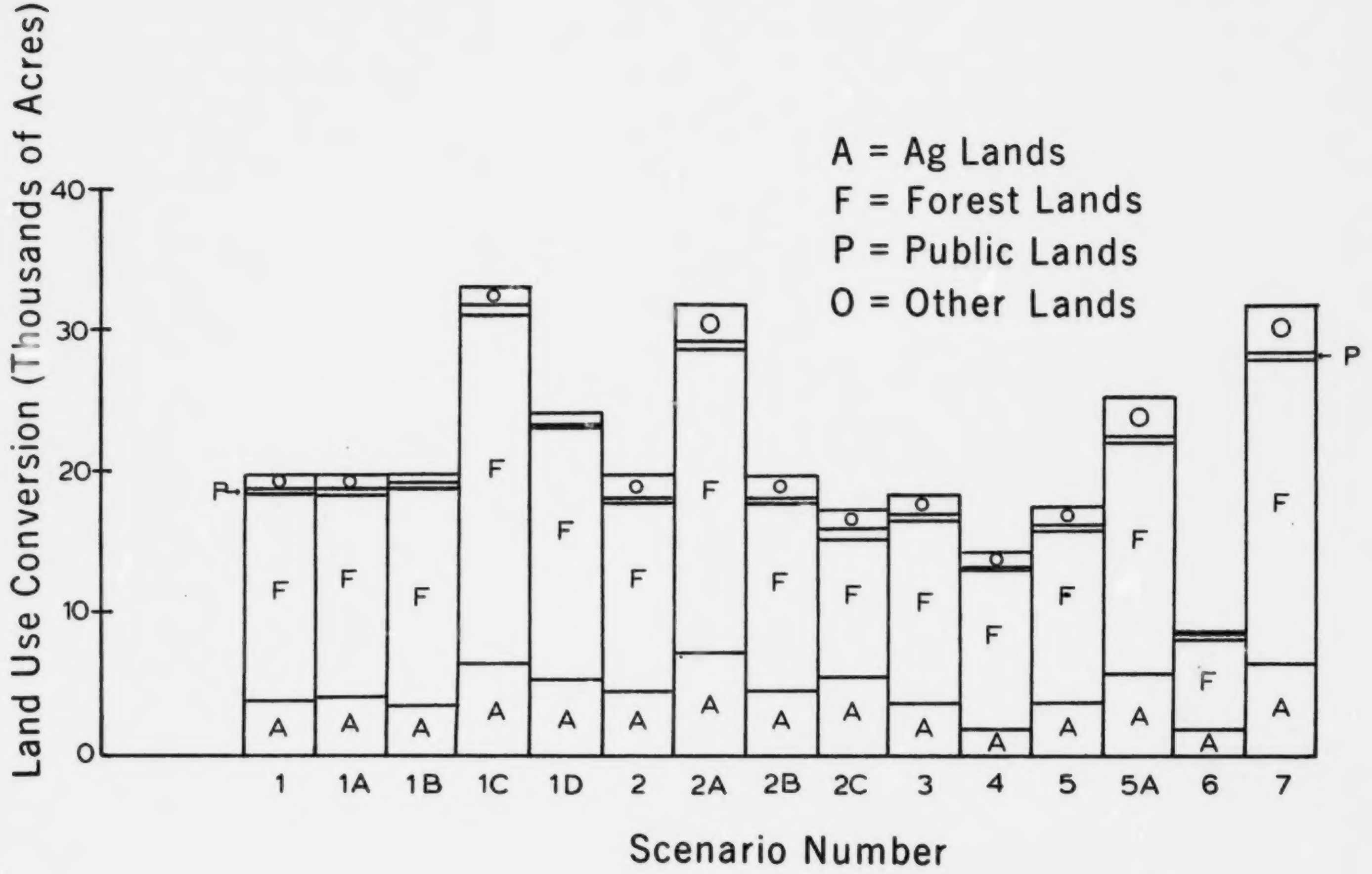


Figure 5-7

ORBES REGION : Total Land Use Conversion By Electrical Generating Facilities, 1975–2000

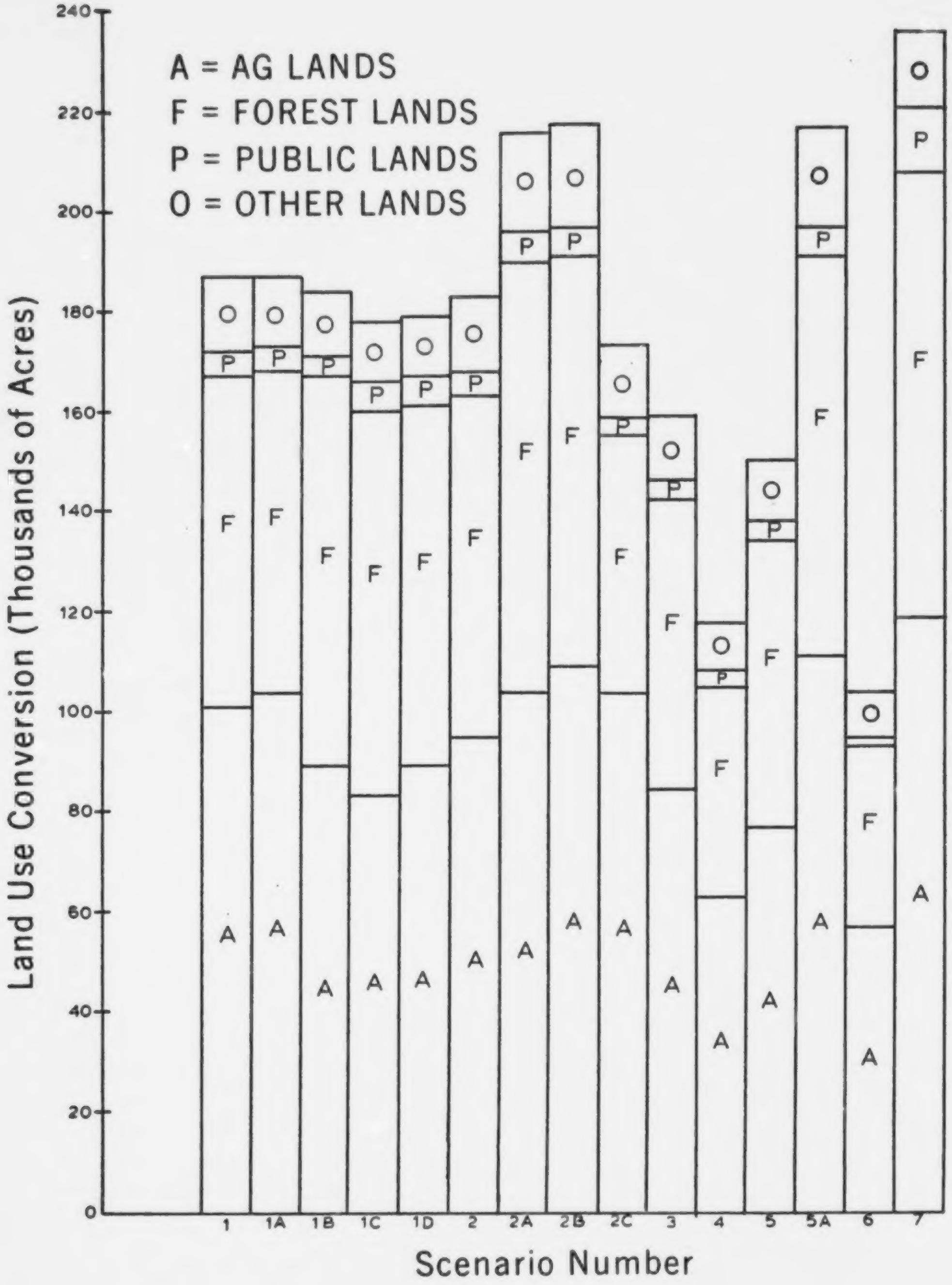


Figure 5-8

ORBES REGION : Total Reversible Land Use Conversion By Electrical Generating Facilities, 1975–2000

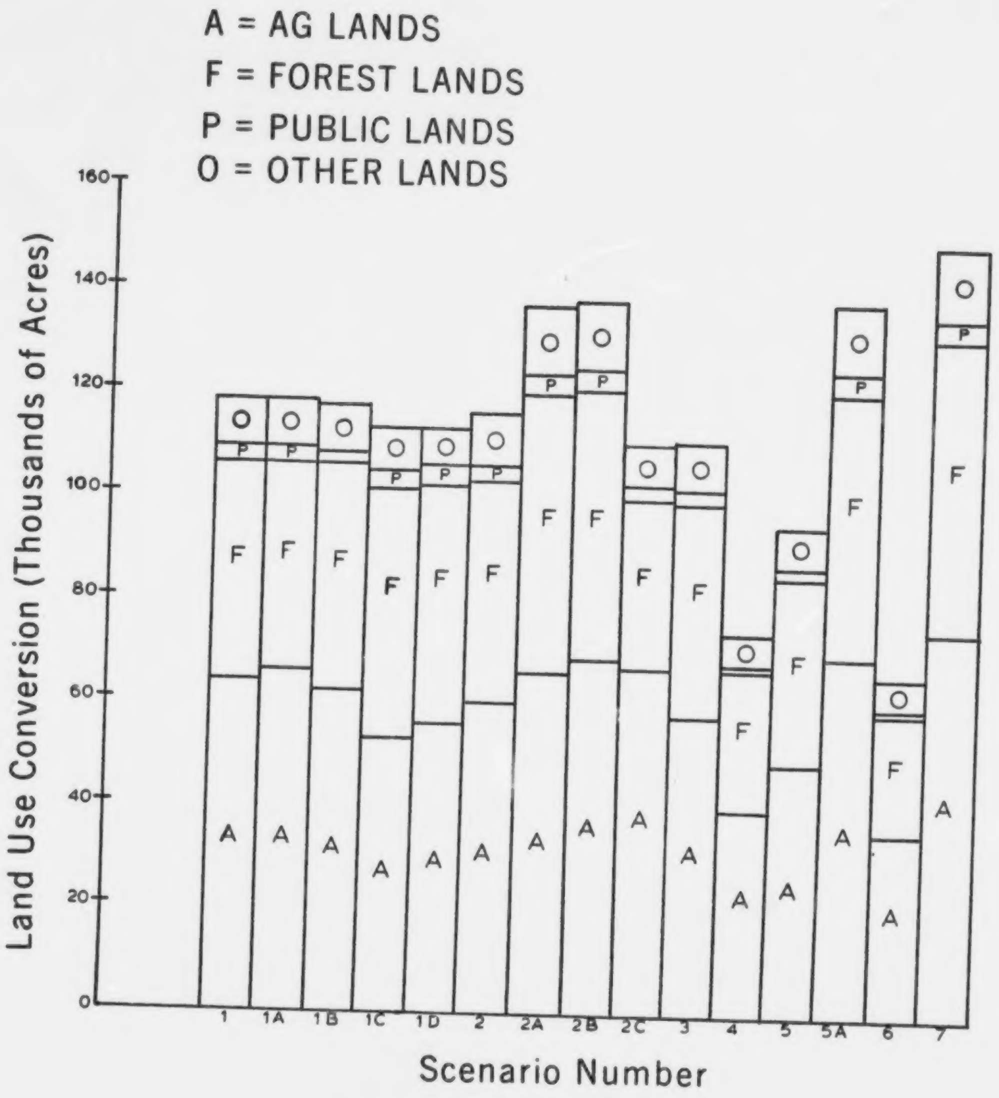


Figure 5-9

ORBES REGION : Total Irreversible Land Use Conversion By Electrical Generating Facilities, 1975–2000

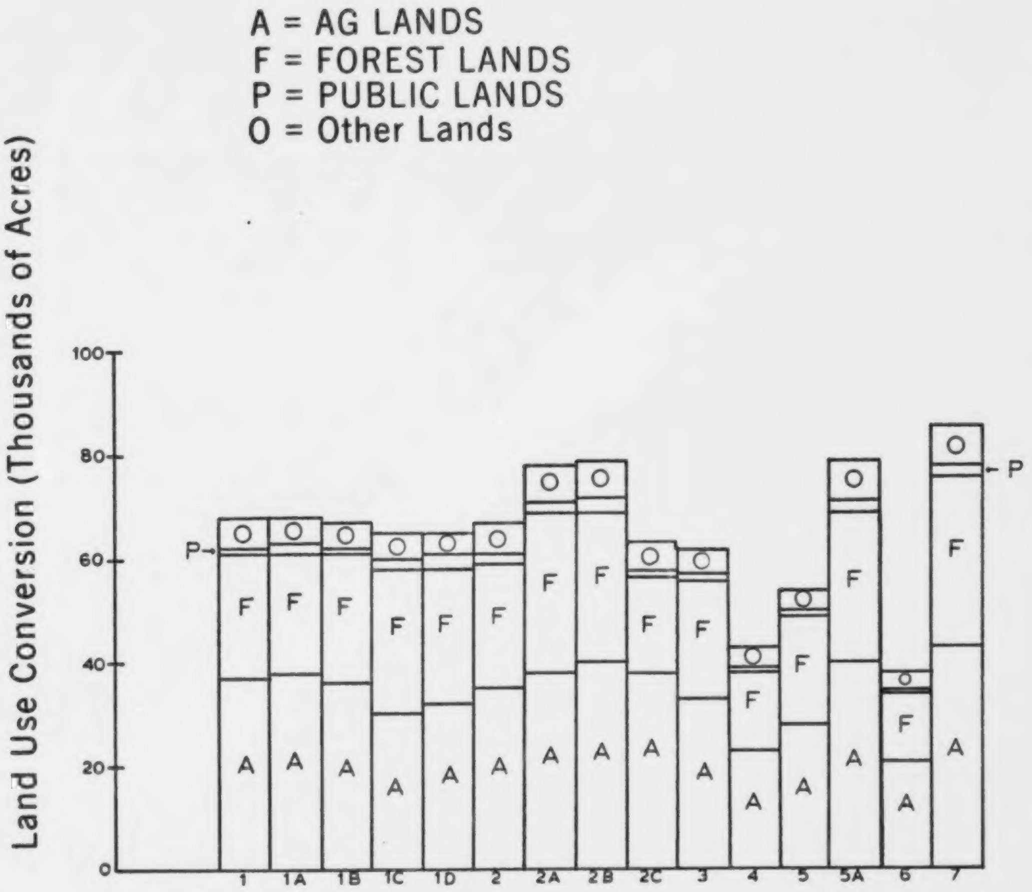


Figure 5-10

To estimate land use requirements for future transmission line R-O-W in ORBES, transmission line characteristics were reviewed from current literature and R-O-W land use requirements were estimated using data for five planned energy facilities in the ORBES region. The average for the five facilities was used as a first approximation of R-O-W land use requirements for the planned and scenario addition energy facilities in the ORBES region.

Table 5-20 presents transmission line requirements for the five planned energy facilities used in making the estimate. Land requirements for transmission line rights-of-way range between 484 to 2,181 acres for those facilities. The greatest acreages are for those facilities requiring the longest lines. When relativized to the ORBES standard coal-fired plant size of 650 MWe, transmission line R-O-W requirements range between 262 to 1,677 acres per 650 MWe generated, with a mean of approximately 800 acres per 650 MWe. This value is considerably lower than the 4,700 acres per 650 MWe estimated for existing energy facilities. The lower value probably reflects the use of existing transmission line corridors for new lines and/or the siting of new facilities closer to existing corridors.

TABLE 5-20. TRANSMISSION LINE REQUIREMENTS FOR SELECTED ENERGY FACILITIES IN THE ORBES REGION

Facility	Total Capacity (MWe)	No. and Voltage of Lines	Length of Lines (Miles)	Width of ROW (ft)	Total Land Involved (Acres)	Land Per 650 MWe (Acres)
Ghent (Units I & II)	1,100	N/A	N/A	N/A	703	415
East Bend (Units I & II)	1,200	2-345 kv	13.3	300	484	262
Spurlock (Unit II)	500	345 kv	71	N/A	1,290	1,677
Merom (Units I & II)	980	N/A	74	150	1,345	892
Patriot	1,950	3-345 kv	120	150	2,181	727

The estimated land use requirements for new R-O-W in the ORBES region is 73 percent of the potential land use requirements for new energy conversion facilities (1,100 per 650 MWe). This could result in an additional total land use conversion of 76,000 acres for Scenario 6 (lowest conversion) or 173,000 acres for Scenario 7 (highest conversion).

Most of this land would be reversibly impacted, although this type of impact can involve major land use changes, particularly when transmission line corridors cross forested lands. Approximately 5 to 20 percent of the land required for rights-of-way are irreversibly dedicated to substations, access roads, and support towers.

Land Use Conversion from Coal Surface Mining

From January 1978 to December 1979, the Environmental Systems Application Center, School of Public and Environmental Affairs, Indiana University, conducted an ORBES Support Study titled "A Land Use Analysis of Existing and Potential Coal Mining Areas in the Ohio River Basin Energy Study Region." This support study was directed by Daniel E. Willard. The following results from that study are presented here to provide a more complete documentation of energy-related land use conversion in the ORBES region.

In the ORBES region, approximately 1.6 million acres (about 1 percent of the ORBES region total) have been affected by the surface mining of coal, although only 18 percent of the total surface-minable reserves has been mined. Surface minable reserves constitute only about 17 percent of the total coal reserve base in the ORBES region. Because of physiographical differences, approximately two acres of land must be displaced in the Appalachian Coal Province to yield the same amount of coal as one acre in the Eastern Interior Province.

Agriculture is an important land use in the Eastern Interior Basin, while forestry or the timber reserve is relatively unimportant. The converse is true of the Appalachian Basin. The greatest potential for conflicts between agriculture and surface mining occurs in Illinois. For forestry, the potential for conflict is greatest in central and southern West Virginia.

Historical trends in surface mining are more apparent than regional trends. Mining has progressed from small, localized operations with a moderate impact upon the topography to large, extensive operations which mine deeper, move more spoil, and can dramatically alter the natural topography. Both spoil grading and revegetation exhibit definite historical trends. Older operations have minimal grading of spoil and extensive natural revegetation. Contemporary operations grade spoil to nearly original contour and extensively replant the mined area (with varying degrees of success). The kinds of species planted have also changed through time. Originally, trees were planted extensively; now forage species are most commonly sown. Post-mining land use has also changed, as is reflected in planted species, from forest-related uses to pasture, particularly in Illinois and Indiana.

Reclamation for permanent land use usually takes more than two years after mining operations cease. In fact, the total regional area affected by surface mining, about 400,000 acres (25 percent) have been affected for at least 10 years and have been reclaimed only partially. Data for the remaining 75 percent are incomplete. The amount of time and money necessary to restore a site according to the Permanent Regulatory Program of the Surface Mining Control and Reclamation Act of 1977 will be higher in the Appalachian Province than in the Eastern Interior Province.

5.3 TERRESTRIAL ECOLOGY

Impacts on terrestrial ecosystems in ORBES from energy-related facilities can be grouped into two major types, direct displacement impacts and pollutant transport impacts. Direct displacement impacts--vegetation removal, loss of wildlife habitat, direct impacts on wildlife, soil disturbances--are those impacts resulting from irreversible and reversible land use conversions associated with construction activities. Irreversible land use conversion results in permanent losses of primary productivity and wildlife habitat in the affected areas. The magnitude of direct displacement impacts from irreversible land conversions is dependent on the particular habitat displaced and its associated characteristics (i.e., species diversity, evenness, and composition). Reversible land use conversions result in short or long-term losses in primary productivity and wildlife habitat. Such conversions occur largely due to land clearing for temporary roads, nonpermanent structures and transmission line rights-of-way (R-O-W). Of the three, displacement impacts from transmission line R-O-W are the most extensive.

Pollutant transport impacts are those resulting from the movement of pollutants through the environment. For example, energy conversion facilities produce a number of potentially toxic residuals ranging from sediment runoff from construction activities to gaseous oxides of sulfur and nitrogen from coal combustion. The ultimate fate and effect of these residuals depends upon pollutant transport mechanisms, which can involve atmospheric, aquatic, and terrestrial pathways.

Energy Conversion Facility Impacts

Direct Displacement--

Construction may eventually remove all existing vegetation from energy conversion facility sites. For six facilities planned or under construction in the ORBES region, the amount of land directly impacted during construction averaged 400 acres per 650 MWe generated (Table 5-1). Most of this land is irreversibly converted to the main boiler facility, coal storage, cooling towers or ponds, ash storage, substations, and miscellaneous roads and parking areas.

Mobile wildlife depart from these areas and less mobile wildlife, typically amphibians and reptiles, fossorial mammals, and baby animals of many kinds, may be unintentionally destroyed. Some of the more tolerant animals may merely move to the periphery of the construction area and not leave the site. If construction of a cooling pond is part of the overall development plan, displacement impacts will increase considerably, although some lake habitat will be created.

Those species displaced from the conversion facility must seek suitable habitat, if available in areas adjacent to the impacted area. Where unusual, rare, or critical habitats are displaced, such as wetlands or isolated habitats at the edge of their geographic range, suitable alternatives may not be available. Under these circumstances, displacement impacts will be more severe and undesirable.

Besides the direct displacement of animal species from their preferred habitat, energy conversion facilities can also interfere with the normal migratory habits of certain species. At a Wisconsin energy facility sited between a major highway and the Wisconsin River, white-tailed deer movements along the river, between foraging and yarding sites, were restricted due to the presence of the facility (Jones 1975). In a similar way, power plant stacks and cooling towers have been shown to be an obstacle to migratory birds (Willard and Willard 1978).

Local traffic of construction personnel to and from the construction area may increase the frequency of road mortality of animals, especially if workers commute long distances through rural areas. In the ORBES region, animals prone to road mortality include white-tailed deer, cottontail rabbit, opossum, box turtle, and snakes.

Energy facilities sited on highly productive lands or forests can result in ecosystem level impacts as well. The loss of prime farmland to energy conversion facilities has been a major concern of agricultural specialists. Facilities sited within large tracts of forest lands can disrupt trophic structures, community energy budgets, and biogeochemical cycles; all essential to the functioning of the forest ecosystem.

Pollutant Transport--

Types--The basic constituents moved by the various pollutant transport mechanisms from energy conversion facilities can be grouped into five categories: (1) oxides, (2) hydrocarbons and other organic compounds, (3) metals, (4) particulates, and (5) sediments. Oxides include those of nitrogen (e.g., NO_2 and those of sulfur (e.g., SO_2). These compounds evolve as coal is burned and are emitted as gases into the atmosphere. The levels of SO_2 emitted during conversion are largely dependent on the coal properties, while NO_x levels depend on the combustion process utilized.

Hydrocarbon and organic emissions occur when some of the coal and/or oil organic material is not completely oxidized. Included in this category are photochemical oxidants, carbon monoxide, and carbon dioxide that are released into the atmosphere.

Metals such as mercury, volatilize and leave the stack as vapors. Other metals such as cadmium, lead, copper, chromium, and arsenic may only partially volatilize and may become mobilized by hydrological transport from ash disposal sites.

Table 5-21 presents the major inorganic and metallic constituents of an eastern coal sample and its ash.

Particulates are defined as dispersed matter existing in either solid or liquid phase. When dispersed through the atmosphere these materials may have toxic effects on vegetation by blocking stomates and preventing the normal gaseous diffusion of CO_2 and O_2. Through inhalation, particulates may adversely affect terrestrial vertebrates.

Sediments usually occur in erosional transport processes. In aquatic systems, suspended sediments increase turbidity, increase the attenuation of light, and adsorb metallic solutes.

Sources and Impacts--The construction of energy conversion facilities causes the erosional transport of adsorbed, dissolved, and suspended materials as the existing vegetation is cleared from the site. Recent studies in deciduous ecosystems report increased cation and nitrate losses via hydraulic export in watersheds where the vegetation has been removed (Likens, et al.

TABLE 5-21. TRACE ELEMENT CONSTITUENTS OF COAL AND COAL ASH

Element	Coal (ppm)	Botton Ash (ppm)	Precipitator Ash (ppm)
Antimony	0.08	< 1.0	4.4
Arsenic	0.87	4.4	61.
Barium	440.	5600.	15,000.
Beryllium	0.29	0.40	5.2
Boron	37.7	83.2	1040.
Cadmium	0.11	1.1	4.2
Chromium	1.8	15.6	8.9
Copper	5.2	68.	238.
Fluorine	78.2	44.6	2880.
Germanium	0.48	< 0.1	9.2
Lead	0.15	1.0	4.0
Manganese	26.2	56.7	374.
Mercury	0.131	< 0.010	< 0.010
Molybdenum	0.87	3.2	12.
Nickel	3.67	14.5	92.9
Selenium	0.98	0.14	16.4
Vanadium	< 13.	< 100.	< 100.
Zinc	16.2	< 8.0	386.

SOURCE: Dvorak, A.J. 1977. The environmental effects of using coal for generating electricity. Argonne National Laboratory and the Nuclear Regulatory Commission. U.S. Government Printing Office, Washington, D.C.

NOTE: Data from a particular batch of coal are not necessarily representative of all coal. Sulfur content (4 percent) indicates use of eastern coal.

1970). Noise and emissions from construction equipment are additional pollutants transported during the construction phase.

A coal-fired energy conversion facility is the source of a number of potential pollutants during normal operation. The most important of these is the emission of gaseous and particulate residuals as coal is burned. The combustion of coal emits oxides of sulfur and nitrogen, carbon dioxide, carbon monoxide, trace elements, and hydrocarbons. The atmospheric transport of these constituents may be localized or dispersed over large areas that involve major airsheds. To date the main interest in the gaseous transport of emitted pollutants has been centered around effects on human health, crop damage, and the effects on the cycling of nutrients in the biosphere and the ecosystem (U. S. Department of the Interior 1978).

Gaseous emissions from coal-fired conversion facilities account for approximately 7 percent of the total primary pollutants being discharged by anthropogenically related activities (U. S. Department of Energy 1977). However, in terms of specific pollutants related to the combustion of fossil fuels, the contribution is greater. For example, between 50 and 80 percent of the atmospheric injection of sulfur oxides is attributed to current human sources of fossil fuel combustion (Granat, et al. 1976).

Sulfur and nitrogen oxides account for approximately 98 percent of the total gaseous emissions from coal-fired generation facilities. Carbon monoxide, hydrocarbons, and other inorganic compounds constitute the remaining 2 percent (U. S. Department of Energy 1977).

Once in the atmosphere, numerous conversions may take place that can give rise to secondary pollutants. Some of these secondary compounds including sulfate aerosols, nitric and sulfuric acids, ozone and peroxyacetyl nitrate may have adverse effects on aquatic and terrestrial systems. The formation of acid rain exemplifies these effects.

Oxides of nitrogen and sulfur undergo a series of reactions that evolve acidic compounds. These oxides are transported by prevailing winds to considerably distant locations, where their acid end-products are eventually scavenged by precipitation. The SO_2 initially emitted at the source is thus deposited as sulfate ($SO_4^=$) some distance away.

The inputs of sulfate anions and hydrogen cations have a profound effect in certain ecosystems. In unbuffered terrestrial systems, sulfate deposition results in cationic losses, including the leaching of aluminum (Cronan et al. 1979). In poorly buffered aquatic systems, decreasing pH, and increased terrestrial aluminum inputs can have toxic effects to organisms.

Under certain meteorological conditions (called plume fumigation) concentrated deposition of pollutants may occur within short distances from the source. In these cases, upward diffusion of gaseous effluents is inhibited by a temperature inversion and organisms within a few kilometers of the source may receive injury. Generally, atmospheric transport involves the movement of pollutants upwind where they are returned to earth by impaction, dry deposition, or precipitation scavenging.

A detailed discussion of the extent of terrestrial ecosystem impacts in the vicinity of energy conversion facilities that might result from local fumigation of this type is presented in the ORBES support study "Subinjurious Effects of Gaseous Sulfur and Nitrogen Emission and Their Conversion Products on Crops and Forests of the Ohio River Basin States" (Loucks et al. 1980).

Another potential source of transportable pollutants is the coal storage area. Windblown coal dust from coal storage piles reduces air quality and leaves deposits on vegetation. Particulate coal "soot" may plug the stomates of leaves, lower photosynthetic activity, and cause leaf necrosis (U. S. Department of the Interior 1978). Surface water runoff from coal storage piles contains coal fines and various concentrations of minerals and trace elements, including heavy metals. The transport of these elements can result in significant impacts to both terrestrial and aquatic ecosystems.

Noise generated during the unloading of unit trains or barges may affect wildlife in the immediate vicinity of the railroad spur or docking facility. Noise effects on wildlife have not been investigated to an extent that can be used for impact assessment. Laboratory studies with captive animals has shown that the effects of intermittant noise on animals are less severe than the effects of continuous noise (U. S. Department of the Interior 1978).

Seepage from ash disposal sites may actively transport solutes. The transport of solutes is influenced by a number of factors and the kinetics are very complex. Specifically, the pH of the leachate, the concentration of trace, organic, or inorganic species in the ash, the permeability of the impoundment site, the redox potential of the leachate, and the permeability of the soils all facilitate the solute transport of pollutants (U. S. Department of Energy 1977).

Impacts of cooling tower plumes on terrestrial communities have been reviewed in an International Atomic Energy Symposium (1977), in a U. S. Energy Research and Development Administration Symposium (1974), and by Dinger (1976). Attention has been focused on two types of cooling towers--mechanical draft and natural draft. To date most observations associated with large cooling towers have been qualitative so the magnitudes of impacts are therefore speculative. Some potential cooling tower impacts in the ORBES region include: ground fog, icing, drift deposition, and cloud seeding. Mechanical draft towers have been associated with occurrences of these phenomena more often than have natural draft towers. Some adverse impacts of these phenomena on terrestrial biotic communities can include damage to vegetation from acidic mist, rain, or snow when stack gases of fossil-fuel power plants and cooling plumes interact, the breakdown of vegetation due to excessive icing, excessive salt deposition on vegetation, and fallout of biocides used to keep power plant circulating systems free of algae. Because of the realized impacts of cooling tower plumes remain to be quantified, it is not practical to speculate on the relative adversities of cooling towers in different parts of the ORBES region.

Alteration of Biogeochemical Cycles--

Of the many elements essential for life, carbon, nitrogen, sulfur, and phosphorus are among the most important. Carbon, in association with hydrogen and oxygen is found in energy-rich materials such as carbohydrates. These together with nitrogen and sulfur are essential for the synthesis of proteins.

Phosphorus is required by living organisms for the transfer of chemical energy within protoplasm. Each of these elements circulates throughout the biosphere in large biogeochemical cycles. The term biogeochemical cycle is used to emphasize a multicomponent system involving geological, biological, and chemical contents, constituents, and processes. Most of the elements occur in various chemical phases depending on the element, the particular cycle, and the characteristics of the specific pool in which the element is present. Biogeochemical cycles may be viewed on either a global and biospheric level or at the ecosystem level. The term nutrient cycling is used within the ecosystem context of biogeochemical cycling.

The cycles of carbon, nitrogen, sulfur, and phosphorus exist as a series of pools interconnected by pathways of transfer between pools. A pool consists of a quantity of a particular element residing in some physical or biological component of the ecosystem or biosphere. For example, the carbon cycle consists of four large pools: the atmosphere, land surfaces (including vegetation and other organisms), the oceans, and marine sediments. All cycles are dynamic and quantities of elements are transferred between the pools during a given period of time. The quantity of material passing from pool to pool per unit time is the flux rate.

Another way of comprehensively approaching flux rates and pool sizes is the concept of turnover time. Simply stated, this value is calculated as the quantity of a particular element in a specific pool divided by the flux rate into or out of that pool. The turnover time thus describes the time required for movement of a quantity of nutrient equal to that in the pool.

On a biospheric level, the flux out of various pools is balanced by flux into the pools. For example, in the carbon cycle one of the major routes of flux is the removal of carbon dioxide (CO_2) from the atmospheric pool by its fixation in organic compounds through photosynthesis. This is balanced by the processes of returning CO_2 to the atmosphere through plant respiration, metabolism, and decomposition. Conceivably, the present carbon cycle has been in overall steady state for long periods of time, but periods of mountain building, vulcanism, shifting climates, changing global areas of land and sea, and changing coverage of land by vegetation may have acted to create shifts in the system over geological time (Reiners 1972).

Ecosystem-level biogeochemical cycling follows the principals of global cycling. However, for a given system there may be inputs of elements to the system that arrive from outside the theoretical system boundaries and exports that are lost from the system entirely. The total amount of nutrients in the biotic and abiotic pools of an ecosystem is termed the nutrient capital of the system. This quantity may be stable, or it may be changing over time as a function of the net gain or loss of the nutrients by various inputs and output processes. Some inputs or outputs from the ecosystem may occur solely as gaseous or dissolved abiotic flux. Other inputs and outputs may occur as organic particulates. Most major input routes involve chemical fixation from the atmosphere, release by weathering or deposition in precipitation. Major routes of nutrient export in deciduous ecosystems occur by conversion to volatile gases and hydrologic export via dissolution in ground and surface waters.

Major biogeochemical cycles, before the intervention of humans, were probably in a steady state condition; where flux rates into and out of pools were balanced over the entire cycle. There is little doubt that the steady state is being disturbed within our own era through the burning of fossil fuels (Reiners 1972).

The biogeochemical cycles of N, P, C, and S show complex involvement with organisms that aid in the negative feedback control of flux rates. As the size of a particular pool or the flux rate between pools is increased or decreased by a disturbance, these feedback controls operate to restore the original condition. The controls usually regulate flux rates by varying their intensity of operation in response to the disturbance. Response must be rapid and in proportion to the magnitude of the disturbance.

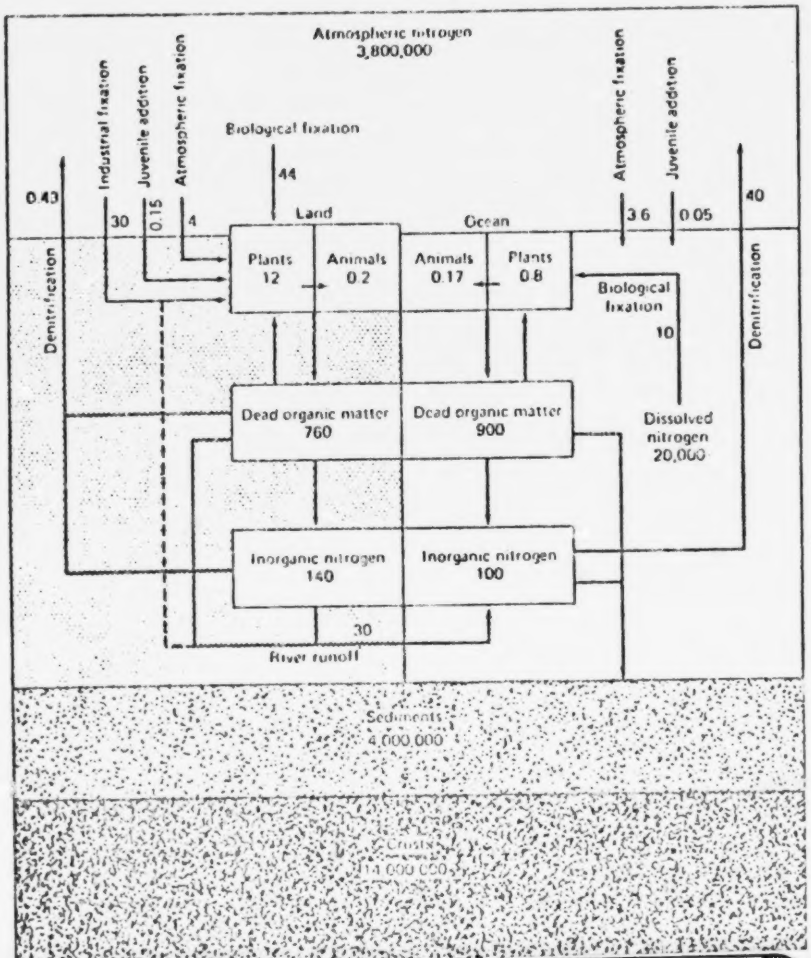
Thus, the regulatory function of negative feedback control of biogeochemical processes is frequently biotic. It usually occurs in situations where flux is mediated by some group of organisms that exert their control by the increase or decrease in population numbers. The nitrogen cycle is an excellent example of a cycle that exhibits such controls.

The Biospheric Nitrogen Cycle--Chemical speciation of nitrogen is mediated in almost all cases by metabolic activities of organisms. Nitrogen exists in various chemical forms; from highly oxidized nitrate (NO_3^-) to highly reduced ammonium (NH_4^+). Within a given reservoir in the biospheric cycle of nitrogen, this chemical speciation may exist. Because many of the pathways are controlled by biotic factors, negative feedback response to disturbances may occur.

Figure 5-11 shows the distribution of nitrogen within various pools of the biosphere and the annual transfer rates between pools. The largest pool of nitrogen exists in mineral and sedimentary deposits. Within the scope of geological time these deposits may become available to the entire cycle, but for most discussions these pools of nitrogen are considered sinks (Soderlund and Swensson 1976). Within the actively circulating portion of the biosphere the largest nitrogen pool is the atmosphere. Atmospheric nitrogen is chiefly diatomic gaseous nitrogen. However, nitrous oxide (N_2O), ammonia (NH_3), ammonium (NH_4^+) and nitrate (NO_3^-) are also present in the atmosphere.

Anthropogenically influenced fluxes into and out of the atmospheric pool occur as nitrogen is industrially fixed for the production of fertilizers and when oxides of nitrogen are released through the combustion of fossil fuels (Soderlund and Swensson 1976). Prior to 1914, mineral nitrate deposits were the main source of the fixed nitrogen required for fertilizers. However, with the development of the Haber process in 1914, mineral nitrate extracts were replaced by industrially fixed nitrogenous compounds (Smith 1974). Processes that industrially fix molecular nitrogen generate nitrogenous compounds from inactive forms in the biosphere.

Increased nitric acid/oxide levels in the atmosphere from the combustion of fossil fuels has been implicated in the occurrence of acid precipitation in the northeastern states (U. S. Environmental Protection Agency 1979). Nitric oxide is converted to nitric acid in the presence of water and returns to earth as acid. While the exact effect of acid rain on ecosystem nutrient


Atmospheric nitrogen
3,800,000
Industrial fixation
Juvenile addition
Atmospheric fixation
Biological fixation
44
0.43
30
0.15
4
Land
Ocean
Atmospheric fixation
Juvenile addition
3.6
0.05
40
Denitrification
Plants
12
Animals
0.2
Animals
0.17
Plants
0.8
Biological fixation
10
Denitrification
Dead organic matter
760
Dead organic matter
900
Dissolved nitrogen
20,000
Inorganic nitrogen
140
Inorganic nitrogen
100
30
River runoff
Sediments
4,000,000
Crust
14,000,000

Reproduced from best available copy.

FIGURE 5-11. BIOSPHERIC NITROGEN CYCLE. Pool sizes and flux rates are in billion metric tons per year.

Source: C. C. Delwiche, "The Nitrogen Cycle." Scientific American, 223(3): 137-146 (1970).

cycling is still unclear, there may be serious consequences for cation leaching and organismal toxification in unbuffered systems.

The Biospheric Phosphorus Cycle--Several elements required by living organisms do not have a significant atmospheric pool. Of these, phosphorus is the most important and has the simplest biogeochemistry. Biospheric phosphorus involves sedimentary cycling, in which the predominant net source is released from igneous and sedimentary rocks by weathering. The major pools are land surfaces and mineral deposits. Leaching and transport by water from the continents to the ocean basins is the major export flux. Eventually, phosphorus deposition in marine sediments is the ultimate sink, where return to the actively circulating portion of the biosphere occurs only in terms of geologic uplift.

Phosphate ($PO_4^=$) is the major form of phosphorus. Plants assimilate phosphate directly from the soil solution; animals excrete organic phosphorus salts in urine; and phosphatizing bacteria convert organic phosphorus to available phosphate. Essentially, phosphorus involves only the soil and aquatic components of the ecosystem nutrient cycle. On the ecosystem level biological control retains phosphorus within the system by tight internal recycling.

The Biospheric Carbon Cycle--During the geologic history of the earth, quantities of carbon, which greatly exceed that which is currently in circulation, were stored in the form of coal, oil, and carbonate minerals. Early in the formation of the biosphere, large amounts of organic material were laid down in beds not undergoing decomposition. As production exceeded decomposition, these organic beds accumulated, and after eons of sedimentation and pressure, these beds became the present day reserves of coal and oil--large carbon pools isolated from biogeochemical cycling except in geological time. Humans are now releasing portions of these stored carbon pools into the active carbon cycle.

Figure 5-12 shows the quantitative relationships of pool sizes and flux rates for the world carbon cycle. The largest pool is sedimentary carbonate mineral deposits. Flux out of this pool is from rock weathering in the terrestrial sphere and solution of carbonate sediments in the oceans. The exact flux rates for these pathways are unknown (Reiners 1972). Flux into this pool is from sedimentation. Carbon is stored in sedimentary rocks in reduced organic form. Some of this is commercially available coal and oil, but most (almost 2000 times as much) is bound in sedimentary minerals such as shales, dolomites, and other carbonates.

Other carbon pools in the global cycle are the atmosphere, land, and oceans. The fluxes that connect these pools are a continuous exchange between the atmosphere and oceans, and the emission of CO_2 through combustion of fossil fuels. These pools and their associated flux pathways constitute the actively circulating portion of the biosphere.

The largest carbon pool within the actively circulating portion of the biosphere is in carbonate and biocarbonate in seawater. Broecker et al. (1979) estimate that this pool, in continuous contact with the atmosphere, is a net sink for excess atmospheric inputs of CO_2 from combustion of fossil fuels. Thus, the ocean may ultimately absorb enormous amounts of excess CO_2.

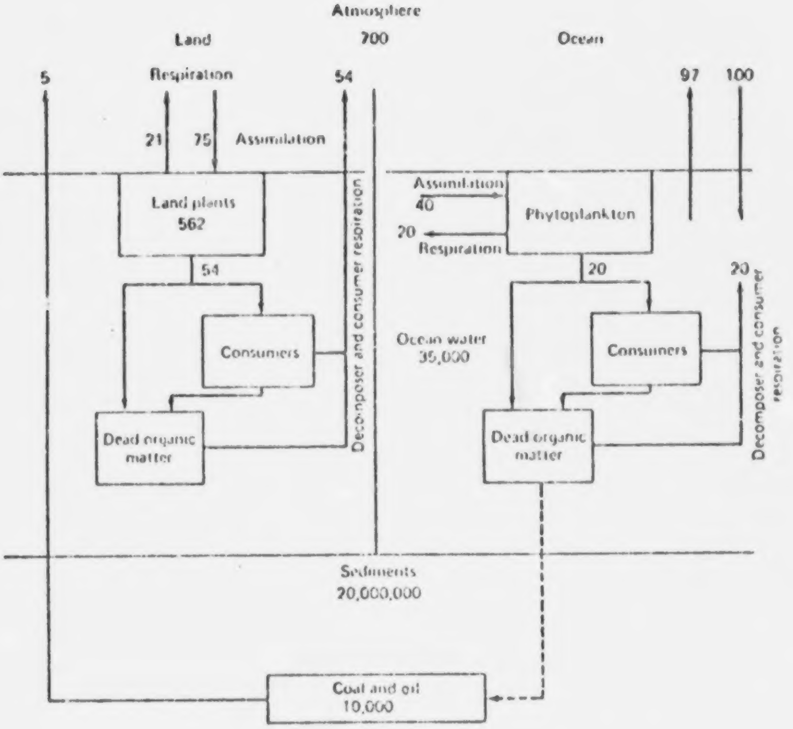

Atmosphere
700
Land
Ocean
5
Respiration
54
97
100
21
75
Assimilation
Land plants
562
Decomposer and consumer respiration
Assimilation
40
Phytoplankton
20
Respiration
54
20
20
Consumers
Ocean water
35,000
Consumers
Decomposer and consumer respiration
Dead organic matter
Dead organic matter
Sediments
20,000,000
Coal and oil
10,000

FIGURE 5-12. QUANTITATIVE RELATIONSHIPS OF POOLS AND FLUXES FOR THE BIOSPHERIC CARBON CYCLE.

Source: Modified from B. Bolin, "The Carbon Cycle." Scientific American, 223(3): 124-32 (1970.

The oceanic carbon pool is approximately 50 times greater than the atmospheric pool. Carbon exists in the atmosphere predominantly as CO_2. A small amount (less than 1 percent) of the atmospheric carbon pool exists as gaseous methane (CH_4), carbon monoixde (CO), and organic carbon. Carbon flux out of the atmosphere occurs as photosynthesis extracts CO_2. This flux to biotic pools has been estimated at 100 billion metric tons per year. Flux out of the atmospheric pool to the oceanic reservoir occurs by the solution of CO_2 in water as carbonate, bicarbonate, and carbonic acid, and is a function of the reaction:

$$CO_2 + H_2O \rightarrow \underset{\text{Carbonic Acid}}{H_2CO_3} \rightarrow H^+ + \underset{\text{Bicarbonate}}{HCO_3^-} \rightarrow 2H^+ + \underset{\text{Carbonate}}{CO_3^=}$$

Atmospheric inputs from land-based pools occur as plant respiration, decomposition, and heterotrophic respiration release CO_2. These combined fluxes account for approximately 100 billion metric tons per year (Reiners 1972). Fossil fuel combustion accounts for an additional 3.6 billion metric tons per year. Oceanic flux to the atmosphere has been estimated to be 98.2 billion metric tons annually. The difference between atmospheric inputs and outputs of CO_2 results in a net annual flux to the atmosphere of 1.8 metric tons (Reiners 1972; Woodwell et al. 1978; Broecker et al. 1979).

Calculations of the global carbon budget are not precise nor complete. Estimates of the atmospheric carbon budget assume a net carbon flux of 1.8 metric tons annually to the atmosphere. Over the past eight years, several reviews of the global carbon budget confirm a steady annual increase in atmospheric carbon as CO_2. Observations since 1958 at the Mauna Loa, Hawaii Observatory provide the best records. Figure 5-13 shows the long-term variation and increase in atmospheric CO_2 content. The upward trend is thought to result from the release of carbon from the combustion of fossil fuels (Broecker et al. 1979).

Because the net annual increase in the carbon dioxide content of the atmosphere is slightly less than half the input from fossil fuel releases, additional CO_2 sinks may be functioning. The two possibilities most discussed have been the oceans and the biota (Woodwell et al. 1978).

The biota could act as a carbon sink with an increase in photosynthetic CO_2 uptake stimulated by the increase in the concentration of carbon dioxide in the atmosphere. While laboratory tests show stimulation of photosynthesis by enhanced concentrations of CO_2, more recently the assumption that atmospheric CO_2 increases stimulate photosynthetic uptake has been questioned (Woodwell et al. 1978). In fact, many of the global carbon budgets in the literature suggest that through practices of land clearing and forest burning there has been a CO_2 flux out of the biotic pool. Woodwell et al. (1978) state that evidence is overwhelming that there has been a steady state reduction in the land area occupied by the earth's forests. This leads to the conclusion that the single major sink for carbon is the oceans. However, Broecker et al. (1979) content that regrowth of previously cut forests have balanced the rate of forest destruction since 1958. Few hypotheses about sinks available for deposition of excess CO_2 can be ruled

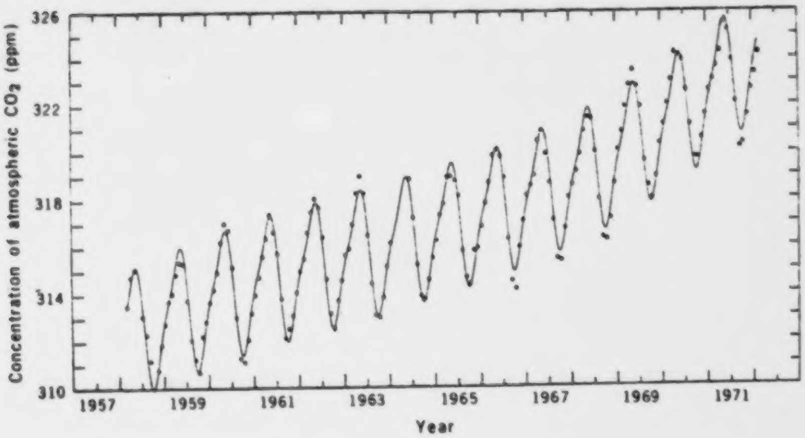


FIGURE 5-13. CHANGES IN THE CONCENTRATION OF ATMOSPHERIC CO_2, 1958-1971.

Source: G.M. Woodwell, R.H. Whittaker, W.A. Reiners, G.E. Likens, C.C. Delwiche and D.B. Botkin, "The Biota and the World Carbon Budget." Science, 179:141. (1978).

out unequivocally. In any case, increase in the atmospheric pool of carbon exists and there is little doubt that the steady state carbon budget is being disturbed by fossil fuel combustion.

The exact impact on the biosphere from increasing the atmospheric carbon pool at an increasing rate is not completely known and has been the subject of considerable discussion. The National Academy of Science reports that the basic model relating CO_2 to global warming is correct, and that an increase in the CO_2 content of the atmosphere will lead to a global warming and significant climatic changes (Science 1979).

The Biospheric Sulfur Cycle--Unlike carbon and nitrogen, the biogeochemical cycling of sulfur is most important at a regional level. The largest pools are in soils and sediments. The major chemical species, sulfate ($SO_4^=$) has a short atmospheric turnover time giving ecosystem-level control of cycling more importance (Granat et al. 1976). Availability of sulfur, primarily as the soluble anion, is regulated by internal cycling within the ecosystem.

Less sulfur is cycled in the ecosystem than carbon and nitrogen, and it is seldom a limiting nutrient. The residence time of sulfate in the vegetation component of the cycle is short. Sulfate is taken up in solution by the standing crop vegetation, not incorporated into biomass, and released through precipitation leaching in the canopy (Eaton et al. 1973). It is thought that organisms use the sulfate anion as an ionic balance to the uptake of cationic nutrients. Thus, sulfur is characteristically in short supply and under strong biological control.

Generally, natural atmospheric inputs of sulfur are aerosols from sea spray, volatile sulfur from biological decay and volatile sulfur from aneorbic decomposition in waterlogged soils. However, at the present time the greatest single flux occurring in the cycling of sulfur comes from anthropogenic sources (Smith 1974; Granat et al. 1976). When burned, the sulfur in fossil fuels is converted to sulfur oxides (principally SO_2). After being discharged into the atmosphere these oxides may be converted to sulfate and sulfuric acids. In the atmosphere sulfate and sulfuric acid have short residence times and are scavenged by precipitation, giving rise to the phenomena of acid rain.

As wet and dry deposition of the sulfuric acid and the anion occur, the biogeochemistry in certain ecosystems may be affected. Some uncertainty exists as to the exact affect of acid deposition on terrestrial and freshwater ecosystems; and the particular effect may vary depending on the ecosystem. Generally, the concentrations of cations and anions are balanced in the hydrologic exports from terrestrial ecosystems. With increased deposition of the sulfate anion in acid precipitation, and because of the high mobility of this anion, sulfate concentrations in hydrologic outputs increase. This results in increased ecosystem cation export in response to ionic balance (Cronan and Schofield 1979).

It must be noted that the exact effects of acid rain on biogeochemical cycles in temperate ecosystems is unclear. Effects may vary depending on the system. For instance, ecosystems in association with calcareous soils which are well buffered by the presence of bicarbonate anions may not be affected as much as unbuffered ecosystems.

The dominating role of anthropogenic sulfur emissions is apparent. As much as 80 percent of the total emissions of sulfur to the atmosphere are from anthropogenic sources (Granat et al. 1976). These emissions are usually confined to a rather limited area and the impact on biogeochemical cycles has thus been regionally and unevenly distributed. The use of global sulfur budgets in impact studies would therefore be less relevant than regional or ecosystem level analysis.

Terrestrial Ecosystem Assessment Model--
Because of the heterogeneous data base and the complexity of the potential terrestrial ecosystem impacts associated with energy conversion, a model similar to that used to assess land use impacts was developed to evaluate the impacts of the ORBES scenarios on terrestrial ecosystems in the ORBES region. Four variables representing terrestrial ecosystem quality, and for which somewhat homogeneous data bases exist, were selected for use in the model. These variables include: percentage of class I and II soils, percentage of forest lands, numbers and quality of natural areas, and numbers of endangered species. The importance of these variables in describing terrestrial ecosystem quality was discussed in Section 2.2.

County level data for the four variables were collected and values for each variable were indexed according to units ranging in value from 1 (low) to 10 (high). These units were weighted equally and summed to produce a county-level index. The county indices were then used in assessing the siting configurations in each scenario by allocating the county index for every 650 MWe sited in that county. For example, if "Nice County" has a county index of 25 terrestrial ecosystem assessment units, then one 650 MWe facility sited in "Nice County" would be assessed 25 units.

State totals were then used to evaluate the various siting configurations represented in the scenarios. States having higher terrestrial ecosystem assessment unit totals for a given scenario would have a higher probably of increased ecological impact under that scenario. No absolute threshold values for assessment unit totals indicate "good" or "poor" ecological quality. Therefore, only relative increases or decreases in ecological impacts can be ascertained from the model by making scenario comparisons, particularly with the business-as-usual case. Since the data base is state dependent, assessment units can be compared across scenarios only for a given ORBES state portion, not across states. Table 5-22 presents a summary of terrestrial ecosystem assessment units for all scenarios.

Transmission Line Impacts

Due to the large land use requirements for transmission line corridors (Section 5.2), displacement impacts on terrestrial ecological systems can be substantial. Terrestrial ecological communities undergo the greatest impacts from transmission line development during the construction phase. These impacts are particularly severe in forested areas where clearcutting causes destruction of existing plant life and results in the displacement of woodland fauna. Clearcutting also causes erosion problems including gullying, loss of soil nutrients, and decreased soil water retention capacity (Kitchings et al. 1972). Compaction of soil by heavy machinery in the R-O-W inhibits natural revegetation.

TABLE 5-22. SUMMARY OF TERRESTRIAL ECOSYSTEM ASSESSMENT UNITS FOR ALL SCENARIOS (1976-2000)

State	Scenario														
	1	1a	1b	1c	1d	2	2a	2b	2c	3	4	5	5a	6	7
Illinois	390	385	390	411	413	356	378	411	679	334	309	345	426	258	442
Indiana	458	472	518	447	452	451	444	470	425	386	331	415	520	301	533
Kentucky	268	264	288	274	241	266	274	264	167	213	148	245	330	129	396
Ohio	300	320	294	178	240	305	434	462	212	247	170	273	367	161	427
Pennsylvania	277	263	246	283	270	270	330	405	216	196	134	222	377	118	350
West Virginia[a]	164	159	167	273	191	156	257	154	87	122	87	140	191	71	249
ORBES Total	1857	1863	1903	1866	1807	1804	2117	2166	1786	1498	1179	1640	2211	1038	2397

[a] No sub-state endangered vertebrate species data were available for West Virginia.

Revegetation in the R-O-W is generally manipulated to include only herbaceous or shrubby species of plants. In forested areas, this can benefit species of animals adapted to edge communities and can provide for greater species diversity. Species which avoid crossing open areas, such as the wild turkey, may be adversely affected.

Transmission line rights-of-way have lesser impacts upon agricultural lands. Farm implements can maneuver beneath the larger lines, which permit continued cultivation in the R-O-W. Permanent loss of agricultural lands is confined only to the area at the base of the transmission line towers. Aerial application of fertilizers and pesticides can be restricted in cultivated fields bisected by transmission lines.

Right-of-way maintenance represents a long-term disruption of the initial habitat. The maintenance of a primitive access road in the R-O-W is necessary to allow for periodic transmission line inspection and repair. In addition, vegetation in the R-O-W must be controlled to prevent the regrowth of trees. Spray application of herbicides is sometimes used to control vegetation, however, this method has inherent environmental problems. Spray drift can cause injury to nontarget sensitive species, particularly to crop species. Accumulation of herbicides in food chains is also a potential deleterious effect. Movement of herbicides via surface runoff can cause adverse impacts in stream systems. Spray management is generally conducted on any given R-O-W once every four years.

Collisions between birds and transmission towers and lines are well documented in the literature (see Willard and Willard, 1976 for a review). Collisions are most frequent during migration, at night, or during bad weather, however, incidents are not restricted to these conditions. Walkinshaw (1956) reports that during a two-day period, characterized by calm, clear weather conditions, 15 sandhill cranes were found dead under a small 30 foot tall, two wire transmission line. Some had completely sheared off wings and legs. Walkinshaw also notes that a roost was located nearby. Other accounts suggest that collisions are more frequent where transmission line corridors cross migratory flyways or are located near refuges and other areas of concentrated bird populations (Willard and Willard 1976).

Cases are reported where, during humid conditions, electrostatic charges from high-voltage transmission lines create conditions directly beneath the lines that are hazardous to humans, and presumably animals.

Ozone, which in sufficient concentrations is toxic to plants and animals, is produced by coronal discharge around 765-kilowatt lines. To date, accumulations of ozone in potentially damaging amounts have not been reported (Dinger 1976).

SECTION 6

SCENARIO COMPARISONS

A variety of alternative plausible futures, or scenarios, were developed for the Ohio River Basin Energy Study (see Sections 3 and 4). The scenarios were derived from an array of policy assumptions about various conditions in the study region from the base period (mid-1970's) through the year 2000. In this section, major land use and terrestrial ecosystem impacts that would be expected under 15 of the ORBES scenarios are identified and discussed. Additional contrasts are made between these effects and current conditions in the ORBES study region (see Section 2). See the Ohio River Basin Energy Study: Main Report (forthcoming) for impact results in other disciplines.

6.1 BUSINESS AS USUAL (Scenario 2)

The single most important factor in terms of total land use conversion under BAU--and indeed under all scenarios--is the growth rate of generating capacity through the year 2000. In general, land resources probably would meet the demand adequately, although the number of suitable sites for generating facilities could be limited by the year 2000.

- Under BAU, the land conversion required by 2000 for all energy-related uses (generating facilities, transmission line rights-of-way, and surface mining for utility coal) could total 991,000 acres (1,548 square miles), or 0.8 percent of the total land in the ORBES region.

- Under BAU, the total land use conversion in the ORBES region due to new electrical generating facilities would be 183,869 acres between 1976 and 2000, in addition to the current 140,700 acres used for electrical generating facilities.

    - By 1985, 26,810 acres in the ORBES region would be irreversibly committed to these facilities and 46,492 acres would be reversibly committed; between 1986 and 2000, 40,395 more acres would be irreversibly committed and 70,172 more acres reversibly committed.

    - In the ORBES portion of Indiana, total land use conversion by 2000 would be 39,540 acres, the greatest commitment among the ORBES state portions. Between 1976 and 1985, 6,951 acres would be irreversibly committed; between 1986 and 2000, 7,468 more acres. Reversible land use conversion between 1976 and 1985 would amount to 12,106 acres; between 1986 and 2000, 13,015 additional acres.

    - In the ORBES portion of Illinois, total land use conversion by 2000 would amount to 28,528 acres. By 1985, 5,286 acres would be irreversibly committed; between 1986 and 2000, 5,268 additional acres. In terms of reversible commitment, 9,003 acres would fall into this category between 1976 and 1985; 8,971 additional acres, between 1986 and 2000.

  - In the State of Kentucky (all of which is in the ORBES region), total land use conversion by 2000 would be 36,433 acres. Between 1976 and 1985, 5,508 acres would be irreversibly committed; between 1986 and 2000, 7,782 additional acres. In terms of reversible commitment, 9,591 acres would fall into this category between 1976 and 1985, and 13,552 additional acres between 1986 and 2000.
  - In the ORBES portion of Ohio, total land use conversion by 2000 would be 31,572 acres. Of this total, 2,936 acres would be irreversibly committed between 1976 and 1985, and 8,576 additional acres between 1986 and 2000. Reversible commitment would amount to 5,115 acres between 1976 and 1985 and to 14,945 additional acres between 1986 and 2000.
  - In the ORBES portion of West Virginia, total land use conversion by 2000 would amount to 19,806 acres. Between 1976 and 1985, 1,582 acres would be irreversibly committed; between 1986 and 2000, 5,642 additional acres. Between 1976 and 1985, 2,755 acres would be reversibly committed; between 1986 and 2000, 9,827 additional acres.
  - In the ORBES portion of Pennsylvania, land use conversion by 2000 would total 27,990 acres. Irreversible commitment would total 4,547 acres between 1976 and 1985 and 5,659 additional acres between 1986 and 2000. Reversible commitment would total 7,922 acres between 1976 and 1985 and 9,862 additional acres between 1986 and 2000.
- Of the total land conversion required for generating facilities by 2000 under BAU, 52 percent would be agricultural lands, 37 percent forest lands, 2 percent public lands, and 9 percent other land uses.
- The estimated land use requirement for new transmission line rights-of-way in the ORBES region is an additional 73 percent of the potential land use requirements for new energy conversion facilities. Under BAU, total R-O-W land use requirements would be 134,224 acres.
- By 1985 under BAU, coal tonnage production in the ORBES region would increase by 162 million tons per year over 1974 levels (439.7 million tons per year). As a result, 111 new standard mines (each producing 1.5 million tons per year) would be opened; 64 would be underground mines and 47 would be surface mines. By 2000 under BAU, production would increase by 376 million tons per year over 1974 levels and 267 new standard mines would be opened (171 underground and 96 surface).
  - By 1985 under BAU, 46 million tons of low sulfur coal would be consumed by electrical generating units in the ORBES region per year. By 2000, an additional 37.4 million tons would be consumed.
- Under BAU, the surface mining of coal for all purposes within the ORBES region would affect 2.33 million acres between 1976 and 2000; this is approximately 1.5 times greater than the total acreage affected by coal surface mining during the past 100 years.

- Under BAU, 673,000 acres (29 percent of the 2.32 million acres in the ORBES region) would be affected by the surface mining of coal for electrical power generation during the period 1976 through 2000. Of this, 184,000 acres would be affected in the Eastern Interior Coal Province, and 489,000 acres would be affected in the Appalachian Province.
    - One standard 650 megawatt electric, coal-fired power unit would use 1.14 million tons of coal annually, or 17.1 million tons over the period 1985 through 2000. To meet the coal demand of one standard unit supplied entirely by surface-mined coal, 193 acres per million tons would be affected in Illinois (Eastern Interior Coal Province), and 458 acres per million tons would be affected in eastern Kentucky (Appalachian Province).
- Two scaling factors strongly influence estimates of affected surface mine acreages: acreage-to-tonnage ratios and surface-to-total production ratios.
    - At present, surface mining produces approximately half the ORBES region coal, while underground mines produce the remainder. Under BAU by the year 2000, the underground portion would increase.
    - Surface-mining production currently ranges from 19 to 98 percent of total production, depending on the geographical location. Under BAU, these proportions would change to 26 to 60 percent of production by the year 2000.
    - Primarily because of the steeper slopes, a given amount of surface mined coal disturbs 2.4 times as much surface area in eastern Kentucky as in Illinois. In general, this relationship holds between the other Appalachian and Eastern Interior Coal Province states.
- In general, under BAU--as well as under all scenarios--the probability of conflict between prime agricultural land use, steep slope land form, and surface mining would change little from current conditions.
    - Locally, prime farmland conflicts would be more important in Illinois and Indiana and less important in eastern Kentucky and West Virginia; the converse is true of steep slope conflicts.
    - Coal to supply SIP-governed units in the ORBES region originates in the hills of eastern Kentucky, West Virginia, and Pennsylvania; thus, the possibility of conflict with prime farmland is small.
    - Under BAU, the surface mining of coal for scenario units would be 22 percent more likely to affect prime farmland and 6 percent more likely to affect steep slopes than the mining for existing facilities.

- A minimum of two years from the cessation of mining is required to reclaim the land with quick-growing cover species. At present, 151,000 acres in the ORBES region are undergoing to two-year reclamation process. In 2000 under BAU, 220,000 acres would be undergoing this process.
    - Although the Appalachian region contains more sloping land than does the Eastern Interior Coal Province, reclaimed ecological productivity and land use would vary only slightly under BAU--and, indeed, under all scenarios.
- Under BAU for the ORBES region, ecologically related impacts (as measured by terrestrial ecosystem assessment units defined in Section 5.3) would increase 1,804 units by 2000 from the 1976 total of 1,306 units (a 138 percent increase).
    - Between 1976 and 2000 in the ORBES state portion of West Virginia, an increase of 156 terrestrial ecosystem assessment units would result (101 percent); in Ohio, 305 units (103 percent); in Illinois, 356 units (123 percent); in Pennsylvania, 270 units (141 percent); in Kentucky, 266 units (161 percent); and in Indiana, 451 units (216 percent).

6.2 MORE STRINGENT ENVIRONMENTAL REGULATIONS

More Stringent Environmental Regulations (Scenario 1) versus Business as Usual Regulations (Scenario 2)

The land conversion required for all energy-related uses and for electrical generating facilities would increase slightly in the ORBES region under the more stringent environmental regulations case (Scenario 1) from the conversion required under business as usual conditions (Scenario 2). The acreage required for surface mining, however, would decrease slightly under the more stringent case. Terrestrial ecosystem impacts also would increase slightly under the more stringent case.

- Under the more stringent environmental regulations case, the land conversion required for all energy-related uses (generating facilities, cooling reservoirs, transmission line rights-of-way, and utility coal surface mining) would be approximately 1 percent higher in 2000 than under BAU.
    - Approximately 40 standard 650 megawatt electric generating units would be distributed to more central locations under the more stringent case than under BAU.
    - If an average-sized cooling reservoir (975 acres) were to be built for each of the 15 Ohio sites dispersed away from major water sources, an additional 14,600 acres would be required.

  - The more stringent case would result in a 6 percent increase in agricultural land conversion for generating facilities from the conversion required under BAU.

The increased use of scrubbers by electrical generating facilities under the more stringent case would result in a decrease in thermal efficiency. Thus, electrical generating facilities would have to burn more coal to produce the same megawattage as under BAU. To meet the increased needs of these facilities, coal production would be expected to increase slightly under the more stringent case. However, it is not anticipated that any more new standard mines would be opened under the more stringent case than under BAU, and, in fact, the total acreage needed for surface mining of land actually would decrease by the year 2000.

- By 2000 under the more stringent environmental regulations case, only slightly more coal would be produced per year than under BAU; the same number of standard mines would be opened up under each scenario between 1976 and 2000; and electrical generating units would consume substantially more coal under the more stringent case than they would under BAU.
  - By 2000 under the more stringent case, only 15.1 million more metric tons of coal would be produced than under BAU.
  - Under the more stringent case, the same number of new standard mines (275) would be opened as under BAU between 1976 and 2000, although two fewer underground mines and two more surface mines would be opened than under BAU.
  - By 2000 under the more stringent case, electrical generating units would consume 31 million more tons per year than they would under BAU.
- The cumulative acreage that would be affected by surface mining for utility coal for the period 1976 to 2000 would decrease slightly under the more stringent environmental regulations case--to 665,000 acres, compared with 673,000 acres under BAU.
  - Under the more stringent case, the land use requirements of state coal-mining regions for surface mining of utility coal would decrease slightly from BAU requirements: in eastern Kentucky, 27 percent; in Ohio, 24 percent; in western Pennsylvania, 14 percent; in western Kentucky, 10 percent; in Indiana, 10 percent; in West Virginia, 9 percent; and in Illinois, 6 percent.
- In the ORBES region in 2000, terrestrial ecosystem impacts would be greater under the more stringent case (1,857 units) than under BAU (1,804 units). This increase suggests that counties located inland from the Ohio River corridor generally would have higher ecological assessments (as defined in the model) than counties bordering the river.

    - In 2000, terrestrial ecosystem impacts would be less in the ORBES portion of Ohio under the more stringent case (300 units). In all other ORBES state portions, however, the impacts of more stringent case impacts would be slightly to significantly more than those of BAU: in Illinois, 9 percent (390 terrestrial ecosystem units); in Indiana, 2 percent (458 units); in Kentucky, 1 percent (368 units); in Pennsylvania, 3 percent (277 units); and in West Virginia, 5 percent (164 units).

Very Stringent Air Quality Regulations (Scenario 1a) versus More Stringent Environmental Regulations (Scenario 1)

Under the very stringent air quality regulations case (Scenario 1a), land use requirements and terrestrial ecosystem impacts in the ORBES region would not change significantly from those under the more stringent environmental regulations case (Scenario 1).

- The very stringent air quality regulations case would not require any more land for electrical generating facilities than would be necessary under the more stringent environmental regulations case.

- Terrestrial ecosystem impacts in the ORBES region in the year 2000 would be only slightly higher under the very stringent air quality regulations case (1,863 units) than under the more stringent environmental regulations case (1,857 units) because more units are sited in counties off the Ohio River corridor.

    - Under the very stringent air quality case, assessment units would be 4 percent greater (472 units) in the ORBES portion of Indiana and 7 percent greater (320 units) in the ORBES portion of Ohio than under the more stringent case, where the measurements would be 458 and 300 units, respectively. Terrestrial ecosystem impacts would be slightly lower under the former case than under the latter in Illinois (385 versus 390 units), Kentucky (264 versus 268 units), and Pennsylvania (263 versus 277 units).

Very Stringent Air Quality (Scenario 1a) versus Very Stringent Air Quality with Concentrated Siting (Scenario 1b)

Under very stringent air quality regulations with concentrated siting (Scenario 1b), total land use requirements in the ORBES region would not change much from the dispersed siting case (Scenario 1a), although fewer counties would be involved and different land types would be affected. Concentrated siting would cause more terrestrial ecosystem impacts, however, than would dispersed siting.

- Policies encouraging concentrated facility siting would not reduce the total land requirements in the ORBES region to any appreciable extent. For example, total land use conversion for generating facilities would be approximately the same under the concentrated siting case and the dispersed siting case. However, because of changes in the geography of the siting patterns, land use conversions within major categories would change.

    - Concentrated siting would result in a small increase (3 percent) in forest land conversion from the conversion required under dispersed siting (64,200 acres). The ORBES state portion requiring the most forest conversion under concentrated siting would be Ohio--a 9 percent increase over the amount required under dispersed siting in that state portion (8,800 acres).

- Very strict air quality regulations with dispersed siting would require land in 65 counties; very strict air quality regulations with concentrated siting would require land in 29 counties.

- Concentrated siting would result in slightly greater ecological impacts regionwide (1,903 units) in 2000 than would more dispersed siting (1,863 units).

    - Terrestrial ecosystem impacts under concentrated siting would be greater than under dispersed siting in four ORBES state portions: Illinois (by 1 percent), Indiana (by 10 percent), Kentucky (by 9 percent), and West Virginia (by 5 percent). These impacts would be less in Ohio (8 percent) and Pennsylvania (6 percent).

Agricultural Land Protection (Scenario 1c) versus Stringent Environmental Regulations (Scenario 1)

Policies protecting prime agricultural lands (Scenario 1c) could be effective in preserving these lands, but there would be a corresponding increase in forest land conversion from the conversion required under the more stringent environmental regulations case (Scenario 1). Regionwide, terrestrial ecosystem impacts would be about the same under both scenarios, although very significant changes would occur in some ORBES state portions.

- Under agricultural land protection, additional energy facilities are sited in West Virginia because of few suitable nonagricultural sites in Ohio. As a result, 46 percent less land would be required under the more stringent environmental regulations case. In West Virginia, however, 67 percent more land would be required under the former scenario than under the latter for electrical generating facilities.

- Under agricultural land protection, less agricultural land (7 percent less, or approximately 17,000 acres) would be required than under the more stringent environmental regulations case.

- Under agricultural land protection, 76,391 acres of forest land would be required, compared with the 66,592 acres required under the more stringent environmental regulations case.

- Although siting impacts on agricultural soil productivity should decrease under the agricultural land protection case, in the ORBES region overall terrestrial ecosystem impacts would be approximately the same as in the more stringent environmental regulations case (1,857 units versus 1,866 units). The reduction of impacts on agricultural lands in the protection case, however, would cause a shift in impacts by a similar magnitude to the other terrestrial ecosystems.

- Under agricultural protection, terrestrial ecosystem impacts in Ohio would decrease by 40 percent from the more stringent environmental case, because of the siting shift from Ohio to West Virginia. Consequently, impacts in West Virginia under the agricultural protection case would be 66 percent greater than under the more stringent regulations case.

Agricultural Land Protection (Scenario 1c) versus Agricultural Land Protection with Concentrated Siting (Scenario 1d)

The major differences in land use and terrestrial ecosystem impacts between the agricultural land protection case with dispersed siting (Scenario 1c) and the same case with concentrated siting (Scenario 1d) occur at the state rather than the regional levels.

- The agricultural land protection case with dispersed siting and the case with concentrated siting are very similar in their siting patterns; each would require about 4 percent less land for electrical generating facilities than would be required under the more stringent environmental regulations case (Scenario 1) for the entire ORBES region.
  - Scenario addition generating facilities would require land in 29 counties under concentrated siting policies and land in 55 counties under dispersed siting policies.
  - The concentrated siting pattern increases the number of facilities sited in Ohio; thus the land conversion required for electrical generating facilities in that state portion is 58 percent greater than the conversion required under dispersed siting.
- Within each ORBES state portion except West Virginia and Illinois, more agricultural land would be converted under the agricultural land protection case with concentrated siting than under the same case with dispersed siting.
  - Policies requiring concentrated siting would require 7 percent more agricultural lands for energy facilities regionwide than would dispersed siting.
- The agricultural land protection case with concentrated siting would result in a 3 percent decrease regionwide from the terrestrial impacts associated with a dispersed siting pattern. This decrease is greatest in Kentucky (by 12 percent) and West Virginia (by 30 percent). However, concentrated siting would result in a 35 percent increase in Ohio from those impacts that occur with dispersed siting.

6.3 EXPORT OF ELECTRICITY FROM COAL-FIRED UNITS

Coal-Fired Export (Scenario 2a) versus Business as Usual (Scenario 2)

Under the coal-fired exports case with cooling towers (Scenario 2a), regionwide land use requirements for electrical generating facilities and for surface mining would increase significantly from BAU (Scenario 2) requirements. Terrestrial ecosystem impacts likewise would increase significantly.

- The coal-fired exports case would require 222,135 acres for electrical generating facilities between 1976 and 2000, compared with 183,869 acres under BAU.
  - Most of this increase in total land use requirements would occur in the ORBES state portions of Ohio (45 percent), Pennsylvania (20 percent), and West Virginia (65 percent)--the states nearest the northeastern United States--the destination of the exported electricity.
- From 1976 to 2000, 67 more new standard coal mines (48 underground and 19 surface) would be opened in the ORBES region under the coal-fired exports case than would be opened under BAU. In the year 2000 under the coal-fired exports case, 81 million more metric tons of coal would be produced per year by these mines than would be produced by the mines added under BAU.
- Because the coal-fired exports case would result in such a large increase in the surface mining for utility coal, as many as 727,000 acres might be affected under BAU.
  - The ORBES state portion that would be most affected by surface mining for utility coal would be Ohio (207,000 acres); the state portion least affected would be Illinois (48,000 acres).
- Surface mining for coal for all purposes within the ORBES region would affect 2.5 million acres between 1976 and 2000 under the coal-fired exports case, compared with 2.3 million acres under BAU for the same period.
- The increased use of coal to generate more electricity for export would result in a 17 percent increase in regionwide terrestrial ecosystem impacts over BAU impacts.
  - These impacts would be highest in the ORBES state portions of Ohio (42 percent), Pennsylvania (22 percent), and West Virginia (65 percent), where most of the additional facilities are sited to reduce transmission losses.
- Because a higher potential exists under the coal-fired exports case than under BAU for acid rain events, as well as for a possible disruption of present biogeochemical cycles, further reductions in the primary productivity of natural and agricultural systems could occur.

6.4 LOW AND VERY HIGH ECONOMIC GROWTH

Low Economic Growth (Scenario 5) versus Business as Usual (Scenario 2)

The differences between the low economic growth case (Scenario 5) and the historic economic growth case, or BAU (Scenario 2), would range from fairly significant to minor with respect to regional land use requirements and terrestrial ecosystem impacts.

- The low economic growth case would result in a 10 percent reduction in regionwide land conversion for electrical generating facilities from the conversion required under BAU, reflected in about a 10 percent reduction in land requirements in every ORBES state portion.
- Thirty-nine fewer new standard coal mines (24 underground and 15 surface) would be opened between 1976 and 2000 than would be opened under BAU.
    - By the year 2000, 68.5 million fewer tons of coal would be produced per year than under BAU.
- By 2000 the low economic growth case would result in 9 percent fewer regional terrestrial ecosystem impacts than the impacts registered under BAU, ranging from 3 percent in Illinois to 18 percent in Pennsylvania.

Very High Economic Growth (Scenario 5a) versus Business as Usual (Scenario 2)

Under the very high economic growth case (Scenario 5a), regional land use conversion requirements and terrestrial ecosystem impacts would be significantly higher than those expected under BAU (Scenario 2).

- Under the very high economic growth case (Scenario 5a), the land conversion required by 2000 in the ORBES region for all energy uses (generating facilities, transmission line rights-of-way, surface mining for utility coal) would total a little over 1 million acres, or 6 percent higher than the acreage required under BAU.
    - Electrical generating facilities alone would require 18 percent more land than under BAU; the greatest increase would occur in West Virginia (28 percent) and the least in Illinois (10 percent).
- Sixty-four more new standard coal mines (23 underground and 41 surface) would be opened between 1976 and 2000 than under BAU.
    - By 2000 under very high economic growth, 125.1 million more tons of coal would be produced per year than would be produced under BAU.

- By 2000 the very high economic growth case would result in 23 percent more regional terrestrial ecosystem impacts than under BAU, with the increase ranging from 15 percent in Indiana to 40 percent in Pennsylvania.

- Because of the increased total loadings of air pollutants expected under very high economic growth conditions, a higher potential exists than under BAU (Scenario 2) for acid rain events, as well as for a possible disruption of present biogeochemical cycles. Such events and disruption could lead to reduced primary productivity in natural and agricultural systems.

Low Economic Growth (Scenario 5) versus Very High Economic Growth (Scenario 5a)

- Regional land use requirements and terrestrial ecosystem impacts would be significantly higher under the very high economic growth case than under the low growth case.
    - Regionwide, by the year 2000, the very high economic growth case would require about 52,000 more acres (32 percent) than the low economic growth case for electrical generating facilities; among the ORBES state portions, the increase would range from 25 percent in Illinois to 44 percent in West Virginia.

- Under very high economic growth conditions, 337 new standard coal mines (197 underground and 140 surface) would be opened between 1976 and 2000, in comparison to the 267 standard mines (171 underground and 96 surface) that would be opened under the low economic growth case.
    - By 2000, the very high economic growth case would be producing 940.6 million tons of coal per year; the low economic growth case 747 million tons.

- The very high economic growth case would require 15 percent more land than the low economic growth case for the surface mining of coal for power plants and 25 percent more land for surface mining to fill all energy needs.

- In terms of regional terrestrial ecosystem impacts, by 2000 the very high economic growth case would result in 35 percent more impacts than those that would be registered under the low economic growth case; the increase among the ORBES state portions would range from 23 percent in Illinois to 70 percent in Pennsylvania.

6.5 VERY LOW ENERGY GROWTH

Very Low Energy Growth (Scenario 6) versus Business as Usual (Scenario 2)

In terms of land use and terrestrial ecology, the very low energy growth case would entail the lowest land use conversion and the fewest terrestrial ecosystem impacts of all the scenarios.

- Land use conversion under the very low energy growth case would amount to 104,274 acres by the year 2000, or 43 percent lower than the amount under business as usual conditions.
  - The reduction of land use requirements from BAU among the ORBES state portions would range from 35 percent in Illinois to 56 percent in West Virginia.
- The very low energy growth case also would result in the fewest regional terrestrial ecosystem impacts in 2000 (1,038 assessment units) of all scenarios; this total is 42 percent lower than under BAU.
  - All ORBES state portions would experience fewer terrestrial ecosystem impacts under the very low energy growth case, ranging from 28 percent fewer in Illinois to 56 percent fewer in Pennsylvania.

6.6 HIGHER ELECTRICAL ENERGY GROWTH

High Electrical Energy Growth (Scenario 7) versus Business as Usual (Scenario 2)

The high electrical energy growth case (Scenario 7) would result in the greatest land use conversion and the most terrestrial ecosystem impacts of any scenario analyzed for impacts in these areas.

- Under the high electrical energy growth case, land conversion for all energy uses (generating facilities, transmission line rights-of-way, and surface mining for utility coal) would total approximately 1.1 million acres (1,740 square miles) by 2000. This acreage is 12 percent higher than under business as usual (Scenario 2) and represents 1 percent (190,377 square miles) of the total land in the ORBES region.
- Among the ORBES scenarios, the greatest land conversion for electrical generating facilities (236,945 acres) would occur under the high electrical energy growth case. This amount is 29 percent higher than under BAU.
  - In terms of the total land within the region (121.8 million acres), the generating facility land requirements under the high electrical growth case would represent only 0.2 percent; thus, land resources do not appear to be a limitation. However, the number of suitable sites for generating facilities could be limited by the year 2000.
  - The high electrical growth case would not result in the greatest land requirement among scenarios in four state portions: Illinois, Ohio, Pennsylvania, and West Virginia.
- The high electrical energy growth case would result in the highest regionwide terrestrial ecosystem impacts in 2000 (2,397 units) of

of the other scenarios. This total is 33 percent higher than under BAU.

  - All ORBES state portions would experience more terrestrial ecosystem impacts under the high electrical growth case than under BAU. This increase would range from 18 percent in Indiana to 60 percent in West Virginia.

- Because the high electrical energy growth case probably would result in increased total loadings of air pollutants, a higher potential exists than under BAU for acid rain events, as well as for a possible disruption of present biogeochemical cycles. Such events and disruptions will lead to reduced primary productivity in natural and agricultural systems.

6.7 ALTERNATIVES TO COAL EMPHASIS

Natural Gas Emphasis (Scenario 4) versus Business as Usual (Scenario 2)

The natural gas emphasis case (Scenario 4) would require substantially less land conversion and result in substantially fewer impacts on terrestrial ecosystems than would BAU (Scenario 2).

- Regionwide, the natural gas emphasis case would require 36 percent less land for electrical generating facilities than would the BAU case in 2000.
  - Under the natural gas emphasis case, Kentucky would experience 43 percent less land requirements for electrical generating facilities than under BAU. The Ohio portion of the ORBES region would experience 47 percent less. These two states would exhibit the greatest decreases of all ORBES state portions.
- Under the natural gas emphasis case, 133 fewer new standard coal mines would be opened between 1976 and 2000 than would be opened under BAU. This difference represents 75 fewer underground mines and 58 fewer surface mines.
  - By 2000 under the natural gas emphasis case, 282 million fewer tons of coal would be produced per year than would be produced under BAU.
- Terrestrial ecosystem impacts would be 35 percent lower regionwide in 2000 under the natural gas emphasis case than they would be under BAU.
  - All ORBES state portions would experience a reduction from BAU impact levels under the natural gas case, ranging from a 13 percent reduction in Illinois to a 50 percent reduction in Pennsylvania.

Nuclear Fuel Emphasis (Scenario 2c) versus Business as Usual (Scenario 2)

Policies encouraging the increased use of nuclear-fueled generating capacity (Scenario 2c) would result in slightly fewer land requirements than under business as usual conditions (Scenario 2). Terrestrial ecosystem impacts also would be about the same under both scenarios. This decrease is primarily due to the lower total capacity additions required for the nuclear fuel case (96,969 MWe) than in the BAU case (104,919 MWe) (see Table 4-2).

- The land requirements for generating facilities under the nuclear emphasis case would be about 5 percent lower than the BAU requirements.
    - The ORBES state portion that would be most affected by a nuclear fuel emphasis is Illinois, which would experience an 86 percent increase in land requirement over that of BAU.
    - Land requirements would decrease in West Virginia (by 13 percent), Ohio (by 29 percent), Pennsylvania (by 32 percent), and Kentucky (by 36 percent), because fewer generating facilities would be sited in those states under nuclear emphasis than under BAU.
    - Land requirements under nuclear emphasis would be essentially the same as those under BAU in Indiana.
- Policies that encourage increased numbers of nuclear-fueled units would result in the highest relative conversion of agricultural lands in comparison to all other scenarios examined--59 percent more than under BAU.
    - In the ORBES region, 11,815 acres of agricultural land would be required under nuclear emphasis--a 17 percent increase over BAU requirements.
    - Of the total agricultural land required under an emphasis on nuclear fuel, 39 percent would be in Illinois.
- Among all scenarios, the lowest relative conversion (31 percent) of forest land in the ORBES region would occur under the nuclear fuel emphasis case. This forest conversion would be 13 percent lower than BAU conversion.
- Under the nuclear fuel emphasis case, 128 fewer new standard coal mines would be opened than would be opened under BAU. This reduction includes 90 fewer underground mines and 38 fewer surface mines.
    - By 2000 under nuclear emphasis, 162.9 million fewer tons of coal would be produced per year than would be produced under BAU.

- Regionwide, the emphasis on nuclear power would result in slightly fewer terrestrial ecosystem impacts in 2000 as under BAU (1,786 units versus 1,804 units).
  - Within the region under nuclear emphasis, the ORBES state portion of Illinois would experience 91 percent more terrestrial ecosystem impacts than under BAU because that state's favorable policies toward nuclear energy would allow many additional units to be sited there.
  - Less favorable policies toward nuclear energy in Kentucky and West Virginia would result in no nuclear units being sited. Thus, under nuclear emphasis, there would be 37 percent fewer terrestrial ecosystem impacts in Kentucky and 44 percent fewer in West Virginia than under BAU.
  - Indiana, Kentucky, and Ohio would also experience fewer terrestrial ecosystem impacts under nuclear emphasis than they would under BAU.

Nuclear-Fueled Exports (Scenario 6) versus Business as Usual (Scenario 2)

The use of nuclear-fueled units to supply additional capacity required for export to northeastern states will require greater land use requirements than the business as usual case.

- Energy conversion facility land requirements for the nuclear-fueled export scenario would be 217,975 acres or 19 percent more than under BAU.
  - ORBES state portion land requirement increases would be greatest in Ohio (54 percent) and Pennsylvania (49 percent). Most of the nuclear-fueled export additions are sited in those states because of their favorable nuclear energy policies and to minimize transmission line losses.
- Under the nuclear-fueled export case, terrestrial ecosystem impacts would increase 20 percent over the business as usual case, from 1,804 assessment units to 2,166 assessment units.
  - Terrestrial ecosystem impacts under the nuclear-fueled export case would be greatest in Ohio (51 percent) and Pennsylvania (50 percent).
  - Impacts would be 1 percent lower than BAU in Kentucky and West Virginia under the nuclear-fueled export case.

Alternative Fuels Emphasis (Scenario 3) versus Business as Usual (Scenario 2)

Policies encouraging the use of alternative energy sources (Scenario 3) would result in decreases from business as usual (Scenario 2) land requirements for conventional energy conversion facilities. Total ecological impacts also would be lower under alternative emphasis than under BAU.

- Under the alternative fuel emphasis case in the year 2000, the land converted for all conventional energy uses (generating facilities, transmission line rights-of-way, and surface mining for utility coal) would total 896,897 acres in the ORBES region. This total is 10 percent lower than BAU conversions. However, the amount of land required for the alternative sources has not been analyzed. Indeed, the total land requirements for the alternative fuel emphasis case might not be very different from those of the scenarios requiring conventional fuels.

- Because fewer coal-fired facilities would be required under the alternative fuel emphasis case, total land conversion for coal-fired facilities would be 14 percent lower than under BAU.

- Under the alternative fuel emphasis case, 78 fewer new standard coal mines would be opened between 1976 and 2000 than would be opened under BAU. This reduction represents 46 fewer underground mines and 32 fewer surface mines.

  - By 2000 under the alternative fuel case, 115.5 million fewer metric tons of coal would be produced per year than would be produced under BAU.

- From 1976 to 2000 under the alternative fuel emphasis case, the surface mining of coal for generating facilities would affect 622,000 acres; this is 51,000 acres (8 percent) less than under BAU.

- Regional terrestrial ecosystem impacts would be 29 percent lower in 2000 under the alternative fuel emphasis case than under BAU.

  - The reduction from BAU impact levels under an alternative fuel emphasis would range among the ORBES state portions from 6 percent in Illinois to 27 percent in Pennsylvania.

  - However, since alternative technology units were not sited in this study, total ecological impacts under an alternative emphasis might be higher than suggested here.

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